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SAFE ATRAUMATIC MANICURE FOR CLIENTS WITH DIABETES

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Abstract. The present study constitutes a comprehensive scientific work aimed at the development and theoretical–methodological substantiation of standards for delivering nail-service procedures to patients with diabetes mellitus. Against the backdrop of the global epidemiological situation, in which diabetes has been diagnosed in more than 589 million people, the use of conventional aesthetic protocols is associated with a clinically meaningful increase in unjustified risks. Among the most unfavorable outcomes are iatrogenic tissue injury, infectious-inflammatory complications, and the creation of preconditions for amputations. The work integrates advances in endocrinology, dermatology, materials physics (tribology), and psychology, making it possible to formulate a coherent concept of "wet" atraumatic manicure as a safe intervention under conditions of diabetes-associated impairment of trophism and tissue repair. Emphasis is placed on the analysis of thermodynamic parameters of rotary instrument operation, clarification of molecular mechanisms of healing under diabetic skin transformation, and the psychosocial determinants of professional interaction within the "specialist–patient" system. Within the study, evidence-oriented algorithms are proposed for selecting abrasive materials, speed modes, and chemical agents, grounded in the principles of evidence-based medicine and the fundamental laws of friction that determine the nature of contact loads and the probability of microdamage.

Keywords: diabetes mellitus, atraumatic manicure, wet technique, tribology, heat generation, diabetic neuropathy, microangiopathy, infectious complications.

CONTENT

INTRODUCTION

Diabetes mellitus (DM) in the twenty-first century has transformed from a purely clinical nosology into a factor that influences safety and standards of service delivery in adjacent, medicine-related service industries, including nail care. According to the International Diabetes Federation (IDF), the prevalence of diabetes among adults aged 20–79 in 2024 reached 11.1%, corresponding to 589 million people, and projections for 2050 suggest an increase to 853 million (≈13% of the planet's adult population) [3,5]. The situation is further complicated by the high proportion of undiagnosed cases: approximately 43% of people living with diabetes (around 252 million) are unaware of the condition [3]. This means that a manicure professional routinely works with clients whose trophism, sensitivity, and capacity for tissue repair may be reduced, even when the diagnosis is not disclosed in a questionnaire or conversation. Consequently, an atraumatic manicure protocol should be viewed not as a "narrow option for diabetics," but as a universal risk-reduction standard for the entire client flow, especially under conditions of latent morbidity [3, 4].

The economic burden of diabetes likewise confirms the systemic nature of the problem: total expenditures in 2024 exceeded USD 1 trillion, and cost growth is largely associated with the treatment of complications, including limb involvement and diabetic foot syndrome [3]. At the same time, a substantial proportion of patients live in low- and middle-income countries, where access to specialized medical podology is limited [3, 5]. As a result, nail-service professionals often become a “first line” for identifying alarming signs (cracks, chronic inflammation of the nail folds, signs of infection/mycosis, ischemic changes) and, accordingly, should possess protocols for safe work and appropriate referral of the client to a physician when complicated disease course is suspected [52, 53].

A key reason for elevated procedural risks in DM is linked to the pathophysiology of diabetic tissue. Chronic hyperglycemia disrupts coordination of the wound-healing phases, in particular by preventing the physiological “switching” of the inflammatory response, thereby sustaining persistent low-grade inflammation and slowing epithelialization even of minimal skin defects [6–8]. At the dermal level, a significant mechanism is the accumulation of advanced glycation end products (AGEs) with the formation of additional collagen cross-links, which alters skin biomechanics: tissues become more rigid and, at the same time, more vulnerable to microcracking under mechanical exposure [13, 14]. A clinical manifestation of these restructurings may be diabetic cheiroarthropathy (“stiff hand syndrome”), in which the skin of the hands thickens and loses elasticity, and manual techniques involving pronounced tissue tension (including aggressive cuticle pushing) increase the risk of tearing and subsequent protracted inflammation [9,15].

An additional critical link is diabetic peripheral neuropathy, in which pain and thermal sensitivity decrease and the “natural feedback” that normally limits excessive pressure and overheating during e-file processing is lost [16,20]. In combination with microangiopathy and reduced tissue perfusion, this creates a “hidden injury” scenario: damage may occur without timely subjective signaling, while healing proceeds more slowly and with a higher probability of complications [8,16]. Practical significance is especially high for hardware (electric) manicure, where local frictional heating under errors of pressure/exposure can lead to thermal tissue injury, and under reduced sensitivity the client may not report discomfort in time [18–20].

In this context, procedural safety should be understood not only as compliance with hygiene and sterilization, but also as management of the physical parameters of the “instrument–skin/nail plate” contact. A tribological approach allows heat generation to be described as a function of the coefficient of friction, normal force, and the speed of movement of the working surface [17, 22]. Diabetic skin is characterized by xerosis and stratum corneum alterations, shifting contact toward unfavorable “dry-friction” regimes and increasing the probability of local temperature peaks [25]. By contrast, introducing liquid/a moist medium can change the friction regime (consistent with the logic of the Stribeck curve) and simultaneously reduce thermal load through cooling and improved heat dissipation [28–29]. The influence of hydration on the coefficient of skin friction is nonlinear and requires standardization of a precisely “controlled” wet technique rather than accidental maceration [25]. An evidence-relevant reference point is also provided by adjacent fields (e.g., high-speed rotary instruments in dentistry), where cooling application reliably reduces temperature-related risks during mechanical processing of tissues/biomaterials [24]. Thus, the physics of contact interaction (heating, friction, lubrication regime) becomes part of the clinical logic of preventing microtrauma and complications in diabetes.

A separate layer of procedural safety is formed by chemical factors: diabetes-associated dryness and microcracks increase vulnerability of the skin barrier and, therefore, the relevance of contact irritants and allergens. In the nail industry, one of the most well-known classes of sensitizers is (meth)acrylates; systematized data on the dermatological risks of nail cosmetic products underscore the importance of controlling allergen load and preventing contact dermatitis [39–40]. For diabetic tissue, such dermatitis is dangerous not only due to subjective discomfort, but also due to an increased likelihood of secondary infection as a consequence of barrier disruption and excoriations, which strengthens the value of protocols focused on hypoallergenicity and minimization of irritant impact [21,39].

Finally, the problem of safe nail care in DM has a pronounced psychosocial dimension. Diabetes as a chronic disease often affects body image and quality of life, and neat, well-groomed hands may serve as a resource for psychological rehabilitation and for reducing stigmatization in social interactions [42–45]. This increases the ethical significance of the professional stance of the nail specialist: refusal of service "because of the diagnosis" reinforces stigma, whereas a competent atraumatic protocol supports both safety and well-being of the client [44–45]. In parallel, the growing market segments of nail care and areas related to diabetic complications indicate the formation of stable demand for "medically oriented" manicure/pedicure as a distinct service niche [48–51].

Thus, the high prevalence and latent nature of diabetes mellitus [3,5], the pathophysiological characteristics of diabetic tissue and wound healing [6–8,13], the combination of neuropathy and microangiopathy with the risk of "hidden injury" [8,16,20], as well as tribologically determined mechanisms of frictional heating and the role of wet technique in risk management [22,25,28–29] create an objective need for scientifically substantiated standards of atraumatic manicure.

The aim of the work is the development and subsequent scientific substantiation of standards for safe atraumatic manicure for clients with diabetes mellitus, based on the integration of the pathophysiology of diabetic tissue, tribology/thermodynamics of e-file processing, and clinical risk management in salon practice.

The author's hypothesis is based on the assumption that a transition from "dry" and cutting techniques to a "wet" low-speed protocol (control of friction/heating, avoidance of cutting instruments, limitation of abrasiveness and allergen load) statistically reduces the frequency of microtrauma, infectious-inflammatory complications, and healing problems in the diabetic population, including undiagnosed clients.

Scientific novelty lies in the fact that, for the first time in nail service, an interdisciplinary model of procedural safety in diabetes is proposed, linking molecular mechanisms of impaired healing (AGEs, dysfunction of the inflammatory phase, microangiopathy/neuropathy) with a physically grounded regulation of e-file parameters (heat generation, “dry/wet” contact regimes, grit, RPM/torque) and standardized screening/referral algorithms.

CHAPTER I. CLINICAL–EPIDEMIOLOGICAL PROFILE AND PATHOPHYSIOLOGY OF DIABETIC TISSUE

In chapter 1 outlines the clinical–epidemiological rationale and pathophysiological mechanisms that make diabetic tissues a high-risk substrate for manicure and periungual procedures: it first frames diabetes mellitus as an expanding global burden (including a large undiagnosed proportion), translating epidemiology into a practical safety problem for the aesthetic industry where clients may present without disclosure yet have impaired repair capacity, higher infection susceptibility, and microvascular/neuropathic compromise; it then details the molecular basis of impaired integument and nail-unit resilience in diabetes—chronic hyperglycemia driving persistent inflammation via disrupted macrophage switching (M1→M2), reduced keratinocyte migration/proliferation, weakened leukocyte function, and AGE-mediated collagen cross-linking that increases stiffness while paradoxically lowering tear resistance—linking these changes to clinical entities such as diabetic cheiroarthropathy that heighten the risk of tissue tearing during aggressive cuticle or fold manipulation; finally, it explains how neuropathy and microangiopathy dismantle the procedure's normal "feedback safety loop," since reduced pain/temperature sensation and autonomic anhidrosis (xerosis, fissures, altered friction) allow thermal and mechanical injury to occur without timely warning, while impaired perfusion and hypoxia slow healing and can convert subclinical microtrauma into delayed inflammation, infection, ischemia, or necrosis—thereby justifying conservative, minimally traumatic, strictly aseptic protocols, avoidance of cutting instruments, reliance on objective risk markers (dryness, fissures, hyperkeratosis, chronic nail-fold inflammation), and prompt medical referral when infection or ischemia is suspected.

1.1. Global Epidemiology as a Risk Factor in the Aesthetic Industry

The modern demographic landscape is shaped by an unprecedented increase in the prevalence of diabetes mellitus (DM), as a result of which this pathology goes beyond the boundaries of a purely clinical problem and acquires intersectoral significance, affecting a wide range of service industries, including aesthetic cosmetology and podological practice. According to the 11th edition of the International Diabetes Federation (IDF) Atlas, in 2024 the global prevalence of diabetes among adults aged 20–79 reached 11.1%, corresponding to 589 million people [1]. Prognostic estimates demonstrate an unfavorable trajectory: an increase in the number of patients to 853 million by 2050 is expected, which would be equivalent to 13% of the planet's population—approximately one in eight adults [3].

In the context of safety of manicure and related procedures, the phenomenon of undiagnosed diabetes is of fundamental importance. Expert estimates indicate that approximately 43% of individuals living with diabetes (around 252 million people) are not informed about the presence of the disease [3]. Consequently, a large group of clients is formed that seeks services without reporting a clinically significant background. In such cases, the nail-service specialist effectively interacts with tissues that possess altered metabolic characteristics and reduced reparative potential, without having sufficient clinical alertness. Under these conditions, atraumatic protocols are more appropriately interpreted not as an option for a limited cohort, but as a universal safety standard applicable to any client flow [26, 27].

The economic burden of diabetes in 2024 exceeded USD 1 trillion (an increase of 338% compared with figures from 17 years earlier) and is largely driven by the treatment of complications, including diabetic foot syndrome and hand involvement [3]. Because more than 80% of patients live in low- and middle-income countries, the availability of specialized medical podology is often limited, which objectively increases the role of manicure professionals as a potential link for early identification of risks and preventive referral [2].

From the standpoint of pathogenesis, the most practically significant factors for nail and periungual structures are diabetes-associated microangiopathy and neuropathy, leading to impaired tissue perfusion, decreased sensitivity, altered skin trophism, and changes in barrier properties. Against this background, even minimal injuries may be accompanied by delayed epithelialization and a tendency toward chronicity, as well as an increased probability of microbial colonization and secondary inflammation. Additional contribution is made by glycemic variability and immunometabolic shifts, which increase susceptibility to fungal and bacterial lesions, complicating the clinical picture of periungual changes.

The consequence of the above mechanisms is the need to build procedural safety on principles of minimizing trauma, strict asepsis, and reproducibility of manipulations. The most vulnerable stages are considered those associated with treatment of the cuticle, lateral nail folds, and the hyponychium zone, where microinjuries often remain unnoticed but become clinically significant under reduced reparative capacity. A rational strategy includes refusal of aggressive techniques, prioritization of hardware and combined methods with controlled exposure, and unconditional compliance with instrument sterilization requirements and reduction of cross-contamination.

Under conditions of a high proportion of undiagnosed cases, formalization of vigilance criteria and proper referral becomes critically important when signs of complicated course are identified: pronounced dryness and fissures, persistent hyperkeratotic restructuring, recurrent inflammatory episodes, signs of mycosis with involvement of periungual tissues, as well as any manifestations of ischemia or infection. The priority is timely referral to an appropriate physician (endocrinologist, surgeon, dermatologist/podiatrist) when an infectious process or impaired healing is suspected, since delay in risk assessment may lead to rapid progression of complications. The organizational and ethical dimension in this context presupposes standardization of history collection, documentation of observed changes, and maintenance of interdisciplinary continuity as a condition for preventing iatrogenic and procedure-associated adverse outcomes.

1.2. Molecular Pathophysiology of the Integument and Nail Unit

The safety of mechanical impact on the skin in diabetes mellitus is determined by profound tissue remodeling at cellular and molecular levels. Chronic hyperglycemia initiates a cascade of interrelated pathological reactions, as a result of which the epidermal barrier function and the regenerative capacity of the dermis are disrupted, and any microtrauma acquires a disproportionately high clinical significance.

Under physiological conditions, repair of microinjuries—typical for invasive cuticle-processing techniques—unfolds through the sequential stages of hemostasis, inflammation, proliferation, and remodeling. In diabetes, wound healing becomes discoordinated, most prominently at the inflammatory phase, where failure of macrophage phenotypic switching represents a key link. Under normal circumstances, dominance of pro-inflammatory M1 macrophages, which debride the wound defect via phagocytosis of microorganisms and detritus, is followed by predominance of M2 macrophages that secrete growth factors (including PDGF and VEGF) and support collagen synthesis and formation of a competent extracellular matrix [6]. A hyperglycemic milieu blocks this transition, fixing tissues in a state of persistent low-grade inflammation and thereby prolonging epithelialization and increasing the probability of complications.

In parallel, functional insufficiency of epidermal cells develops: under elevated glucose concentrations, keratinocytes demonstrate reduced migratory capacity and diminished proliferative activity, which limits closure of even minimal defects in the cuticle region and lateral nail folds. Against this background, microinjuries clinically perceived as a “hangnail” can become portals for a nonhealing defect with subsequent infection [6]. An additional aggravating factor is reduced leukocyte chemotaxis and suppression of phagocytic activity, leading to a deficit of local antimicrobial control and weakening of cutaneous immune defense of the hands [8].

One of the most dermis-specific changes in diabetes mellitus is the accumulation of advanced glycation end products (AGEs), arising from non-enzymatic binding of glucose to long-lived proteins of the extracellular matrix, primarily type I and III collagen, with formation of irreversible cross-links [9]. These molecular modifications transform skin biomechanics: the elastic modulus increases (rigidity and loss of elasticity develop), yet resistance to tearing simultaneously decreases, such that under mechanical loading tissue tolerates deformation more poorly and becomes prone to microfissuring that is often indistinguishable on visual inspection [11, 12]. Thus, skin that appears merely “dry” or “dense” may, in structural terms, be more vulnerable to microtraumatization.

A clinical equivalent of these processes is diabetic cheiroarthropathy (“stiff hand syndrome”), observed, according to reports, in 30–40% of patients [9]. It is characterized by thickening and waxy changes of the dorsal hand skin, development of flexion contractures of the fingers, and a positive “prayer sign” (inability to fully approximate the palms) [10]. Under such conditions, manual techniques requiring marked displacement of the proximal nail fold and tissue tension are associated with an increased risk of tearing and a subsequent prolonged inflammatory response, necessitating refusal from aggressive processing methods in favor of gentler variants.

An additional pathogenic burden is created by diabetes-associated microcirculatory disturbances: thickening of capillary basement membranes, endothelial dysfunction, and reduced tissue perfusion lead to relative cutaneous hypoxia and impaired delivery of substrates required for repair. As a consequence, granulation becomes less effective and matrix remodeling slows, while minimal injuries more readily transition into a long-persisting defect, especially when combined with skin dryness and disruption of the hydrolipid mantle.

No less significant is diabetic neuropathy, which also affects sensory fibers: reduced pain and tactile sensitivity alters the natural "signal" protection against excessive pressure, friction, and overheating. In practice, this promotes unintentional microtraumatization in the periungual zone and delayed recognition of complications, since subjective symptoms may be blunted even when an inflammatory process is developing.

The totality of metabolic, immune, and biomechanical changes substantiates the need for protocols oriented toward minimal trauma and strict adherence to asepsis, with emphasis on controlled impact and a predictable depth of processing. Priority is given to excluding manipulations that provoke tissue tension and tearing, as well as to early identification of adverse signs (persistent erythema, maceration, fissures, localized tenderness, serous-purulent discharge), because it is precisely within this clinical niche that the most consequence-intensive diabetic complications tend to form.

1.3. Neuropathy and Angiopathy: Loss of Feedback

In typical practice, the safety of a manicure procedure substantially relies on the client's subjective sensory feedback, which makes it possible to promptly stop impact when pain or excessive heating is felt. In diabetic peripheral neuropathy (DPN), this physiological protective loop loses reliability, because damage to afferent fibers reduces the informativeness of pain and temperature signals and, therefore, the possibility of early recognition of a damaging factor.

Sensory dysfunction in DPN, affecting up to 50% of patients, typically begins in distal extremities in a “stocking-and-glove” distribution [16]. Predominant involvement of small fibers, including C fibers, leads to attenuation of temperature and pain perception, such that a clinically meaningful local temperature increase may not be accompanied by subjective discomfort. Under hardware processing conditions, this creates a risk of thermal injury: heating of the working surface to 60–70°C is already sufficient for protein denaturation and formation of a deep burn; the absence of pain eliminates an early “stop signal” and contributes to prolonged exposure [18].

The autonomic component of neuropathy further increases vulnerability of the skin through disorders of sympathetic regulation of eccrine sweat glands. Developing anhidrosis leads to pronounced xerosis, fissuring, and impaired barrier properties of the stratum corneum, and also modifies the coefficient of skin friction, which increases the likelihood of microdamage during mechanical processing and contact with rotating instruments [20]. Thus, even under ostensibly “gentle” impact, the risk of subclinical tears and maceration in periungual zones increases.

A key pathophysiological background that amplifies the clinical significance of any microtrauma is diabetic microangiopathy. Thickening of the capillary basement membrane and endothelial dysfunction impair tissue perfusion and oxygen delivery, forming a predisposition to localized ischemia [8]. Under these conditions, energy support for repair after the procedure becomes insufficient, which increases the probability of necrotic changes and delayed recovery even after minimal injury.

The combination of sensory deficit and microcirculatory impairment forms a clinically unsafe situation of “hidden trauma,” in which damage arises and progresses without timely subjective warning. Here, the thermal factor becomes particularly salient: local overheating at high rotational speed, prolonged retention of the bit on a single area, or insufficient heat dissipation can induce coagulative necrosis, which initially may manifest only as skin discoloration and edema, while full-fledged symptomatology develops with delay.

Xerosis and fissures in autonomic neuropathy create additional “gateways” for microbial invasion and support chronic low-grade inflammation of periungual tissues. Superficial microfissures, invisible during rapid inspection, are clinically significant due to impaired barrier function and reduced efficiency of local defensive mechanisms; taken together, this increases the likelihood of paronychia and secondary infection under minimal traumatic impact, particularly in the presence of concomitant dermatoses or mycotic involvement.

Given the high frequency of DPN and the common latency of its manifestations, systematic prevention of complications within manicure interventions logically rests on identifying objective markers of risk and adopting a conservative assessment of tolerance to mechanical and thermal impact. Such markers include pronounced dryness and “waxy” skin texture, fissures, areas of hyperkeratosis, signs of chronic inflammation of the nail folds, as well as any changes indicating trophic deterioration. When an infectious process or ischemic compromise is suspected, medical referral is considered the priority, because it is precisely the combination of neuropathy and microangiopathy that determines the maximal probability of an unfavorable course of injuries [8].

Table 1 provides a comparative characterization of healthy and diabetic skin in the context of manicure.

Table 1. Comparative characteristics of healthy and diabetic skin in the context of manicure (compiled by the author based on [8]).

Parameter	**Healthy skin**	**Diabetic skin**	**Implications for the procedure**
Elasticity (Young's modulus)	High, elastic deformation	Low, rigidity (collagen glycation)	Risk of cuticle tears during pushing back with a pusher.
Regeneration	Phases are replaced within 3–7 days	Stalling in the inflammatory phase	Prohibition of cutting instruments (scissors, nippers).
Sensitivity	Preserved (protective reflex)	Reduced or absent (neuropathy)	Inability to rely on the client's sensations.
Hydration	Normal	Reduced (anhidrosis)	Altered coefficient of friction; need for moisturizing.
Immune status	Normal	Reduced chemotaxis of phagocytes	High risk of fungal and bacterial infections.

Thus, diabetic peripheral neuropathy and microangiopathy fundamentally disrupt the "safety loop" of the manicure procedure: diminished pain and thermal sensitivity deprives the technician of a reliable subjective stop-signal and increases the risk of occult thermal and mechanical injury, while autonomic neuropathy (anhidrosis) accompanied by xerosis and fissuring compromises the barrier, increases friction, and creates portals of entry for infection. Against the background of microcirculatory insufficiency, any microtrauma repairs more poorly and may progress toward ischemic and necrotic changes with delayed clinical manifestation; therefore, prevention of complications should be grounded in identification of objective markers of trophic impairment and inflammation, a conservative choice of technique (minimization of heat and aggressive mechanics, refusal from cutting instruments), and—when infection/ischemia is suspected—priority medical referral.

CHAPTER II. PHYSICS OF E-FILE PROCESSING: TRIBOLOGY AND THERMODYNAMICS

2.1. Mechanisms of Heat Generation During Rotary Exposure

E-file manicure is based on removal of keratinized structures by a rotating abrasive; from the standpoint of biomechanics and contact physics, the "bit—nail plate/skin" interface is appropriately described by tribology, the field that examines friction, wear, and lubrication regimes. The key undesirable factor in diabetes mellitus is frictional heating, because a substantial fraction of mechanical energy is converted into heat within the contact zone. The amount of heat released, Q, can be represented by the following relationship [22]:

$$Q = \mu \cdot N \cdot v \cdot (1 - \eta) \quad (1),$$

where:

μ is the coefficient of friction between the abrasive and the tissue;

N is the normal (compressive) force;

v is the linear speed of the working surface ($v = \omega \cdot r$, where ω is angular speed and r is the bit radius);

η is the fraction of energy expended on bond disruption and material removal;

the term $(1 - \eta)$ reflects the portion of energy dissipated as heat.

For diabetes-associated skin changes, the nonlinear behavior of μ is of central importance: xerosis, hyperkeratosis, and increased rigidity of the stratum corneum shift contact toward a "dry-friction" regime with elements of micro-adhesion and intermittent slip. Under such conditions, even a moderate increase in N does not produce a more "controlled" removal of material; instead, sliding resistance rises and heat generation intensifies, while η may decrease due to reduced cutting efficiency and predominance of deformation–frictional components over true abrasive shearing. Additional contribution is made by altered surface microtopography (fissures, dense hyperkeratotic plaques), which creates local zones of elevated pressure and, consequently, an uneven spatial distribution of heat.

Dry, keratinized skin also exhibits unfavorable thermophysical characteristics: reduced thermal conductivity and limited convective heat loss facilitate local energy accumulation directly at the point of contact. The result may be a short-term yet pronounced temperature spike, capable of arising even with short exposure—particularly when high v is combined with increased N [23]. For the diabetic cohort, this mechanism is clinically significant in a double sense: neuropathic deficit reduces early recognition of overheating, while microcirculatory impairment worsens heat removal and subsequent tissue repair, increasing the likelihood of thermal injury with delayed manifestation.

Given these regularities, priority is assigned to minimizing parameters that directly increase Q, above all the normal compressive force and the duration of continuous contact at a single point, and to avoiding regimes in which the abrasive predominantly "rubs" rather than removes material. A preventive orientation includes techniques that reduce dry friction (pre-procedural correction of pronounced xerosis, segmented work with controlled exposure, selection of abrasiveness and bit geometry in accordance with the specific density of the stratum corneum), because it is precisely the combination of high μ and low heat dissipation that creates conditions for critical overheating under externally standard technique.

2.2. Analysis of "Wet" and "Dry" Grinding: Thermal Consequences

A key element of procedural safety is the choice of the medium in which abrasive processing is performed. In adjacent fields—dentistry and bone surgery—where mechanical drilling is applied to biomaterials comparable in hardness to the nail plate, it has been shown that manipulations performed without cooling are accompanied by a critical temperature rise and may lead to tissue necrosis; irrigation reliably reduces the thermal load [24]. Extrapolation of these patterns to nail service is methodologically justified, because in both settings similar mechanisms of heat generation dominate under high-speed friction and constrained heat removal.

When working on dry skin, the contact regime is often described as a "seemingly more slippery" interaction due to the absence of capillary adhesion; however, compensatory heat removal is practically absent [25]. Under these conditions, the principal share of energy arising in the cutting zone dissipates as heat and accumulates in the nail plate and adjacent tissues, because dissipation is limited by the low thermal conductivity of the keratinized layer and by features of local microcirculation. Experimental observations indicate that without cooling, the temperature in the contact zone may exceed 100°C, whereas the threshold of protein denaturation in skin and matrix lies in the range of approximately 45–50°C, creating prerequisites for coagulative injury even during brief exposure [27].

Introducing liquid into the contact region qualitatively changes the tribological regime. In terms of the Stribeck curve, the presence of a lubricating layer shifts the system from boundary lubrication—where interaction is being implemented through surface (asperities) and local pressure peaks—toward a mixed or near-hydrodynamic regime, in which surfaces are partially separated by a liquid film and the likelihood of "dry" micro-adhesion is reduced [28, 29]. In the safety context, however, the decisive factor is not only friction reduction but also the thermodynamic effect of evaporation: upon heating, water, an emulsion, or a keratolytic composition transitions into the vapor phase and absorbs a substantial amount of energy due to high enthalpy of vaporization (for water, on the order of 2260 kJ/kg) [27]. This transforms moisture into an effective heat-removal agent and limits the temperature rise in superficial layers, particularly when a thin liquid film is continuously renewed and active evaporation occurs.

An additional advantage of a wet medium is more predictable heat distribution across the surface: a fluid film reduces the amplitude of short-lived temperature spikes that arise during point contact of the abrasive with hyperkeratotic areas and fissures, thereby decreasing the probability of local overheating under otherwise correct speed parameters. At the tissue level, this is especially relevant under diabetes-associated changes (xerosis, stratum corneum rigidity, microangiopathy), where physiological mechanisms of heat dissipation and repair are limited and injury may manifest with delay.

Selection of the liquid requires consideration not only of thermophysical properties but also of biological compatibility: aqueous solutions and emulsions provide pronounced evaporative heat removal, whereas aggressive solvents or highly concentrated keratolytics may reduce barrier function of the stratum corneum and increase the risk of irritation. In the presence of microfissures and periungual inflammation, preference is given to agents with controlled osmolality and neutral pH, because damaged diabetic skin demonstrates increased susceptibility to chemical stress.

Integration of a “wet” approach into the processing protocol is appropriately considered as part of a risk-management system: reduction of heat generation by shifting friction into a more favorable regime should be combined with minimization of normal force and limitation of continuous contact time. Such a complex of measures reduces the likelihood of thermal injury to the nail matrix and deeper dermal layers, which is of fundamental importance in diabetes, where even minor burns and microtrauma are prone to prolonged inflammation and complicated course.

2.3. Effect of Hydration on the Coefficient of Friction and Abrasiveness

Tribological studies of the skin demonstrate a nonlinear, multifactorial dependence of the coefficient of friction on the hydration level of the stratum corneum. The value of μ is determined not only by surface chemistry, but also by microrelief, elastic modulus, true contact area, and the pattern of deformation under shear. Consequently, changes in hydration shift the "abrasive—skin" system into a different mechanical interaction regime, which has direct relevance for evaluating the traumatic potential of e-file processing.

For dry skin, relatively low μ values are typical, while the stratum corneum simultaneously exhibits increased rigidity and a tendency toward microfissuring. This combination creates an unfavorable wear profile: the abrasive engages the material less effectively and, instead of controlled removal, produces predominantly superficial friction and localized deformation with the formation of stress-concentration zones. A practical consequence is the need to increase abrasive aggressiveness and/or rotational speed in order to achieve a noticeable effect, which raises the likelihood of overfiling, tissue delamination, and frictional overheating—especially in the presence of diabetes-associated xerosis and a glycated, mechanically stiffer matrix.

With moderate hydration (damp/moist), μ increases in a regular fashion; in some studies, the increase is multiple—up to approximately 13-fold compared with a dry surface—an effect associated with softening of the stratum corneum, a reduction in its elastic modulus, and an increase in the true contact area between interacting surfaces [25]. Hydration shifts keratinized structures from a "glass-like" state toward a more viscoelastic condition in which shear stress leads not to brittle cracking and abrasive wear, but to plastic deformation with separation of layers. In the context of cuticle processing and hyperkeratosis reduction, this implies a shift of the removal mechanism toward controlled sloughing and "rolling-off," rather than aggressive filing that carries a risk of creating a defect deeper than the intended target layer.

The transition to viscoelastic tissue behavior modifies the requirements for tool selection and exposure parameters: the use of softer abrasives (fine grit) and lower RPM becomes feasible without loss of effectiveness, because the increase in μ and contact area provides sufficient traction for removing softened material without the need to increase normal compressive force. At the same time, the probability of uncontrolled penetration into viable structures decreases: increased tissue compliance improves predictability of keratinized mass detachment and reduces the likelihood of linear tears in the proximal and lateral nail folds.

Accordingly, a "wet" technique provides a dual safety mechanism: on the one hand, thermal load decreases due to improved heat dissipation and evaporative cooling; on the other hand, the biomechanics of keratinized tissue removal are transformed, reducing the need for aggressive modes and minimizing injury risk. For patients with diabetes—where xerosis, increased skin stiffness, susceptibility to microdamage, and delayed repair coexist—this redistribution of risk factors is of principal clinical importance and supports the preference of protocols that rely on controlled hydration of the working zone (see Figures 1 and 2).

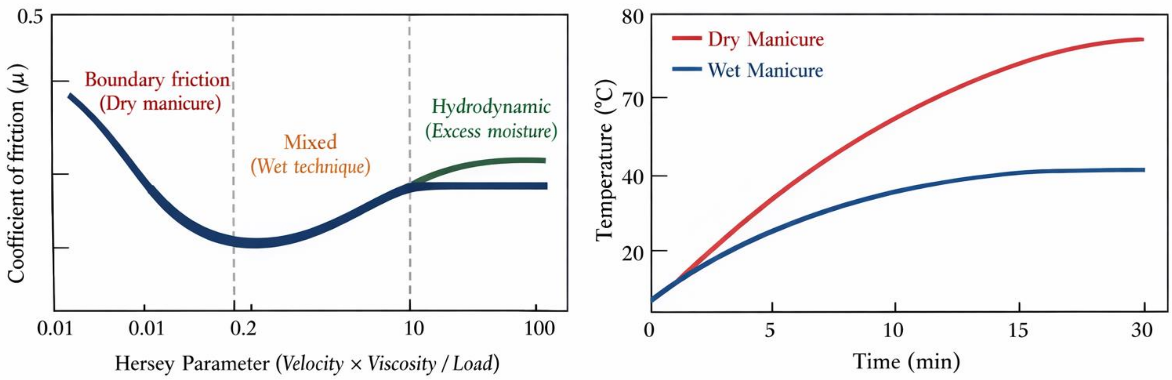

Fig. 1. Stribeck Curve (Skin Adaptation) (compiled by the author based on [25]).

Figure 2 demonstrates the tissue heating dynamics using various techniques.

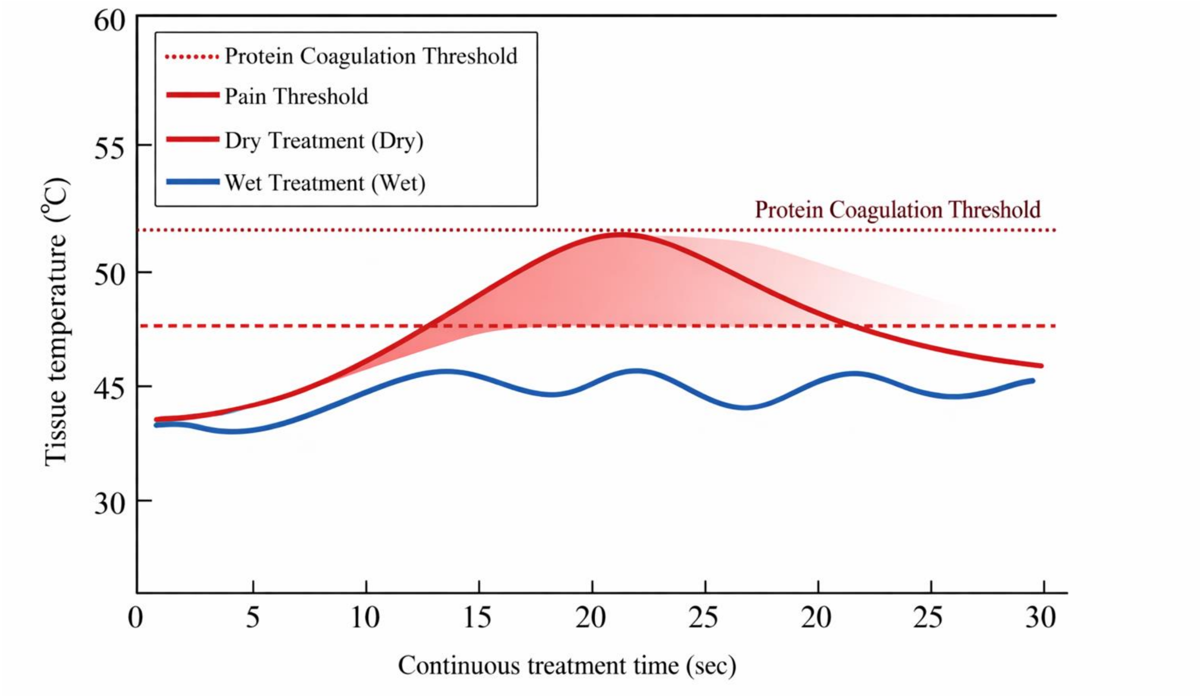

Fig.2. Tissue Heating Dynamics Under Different Techniques (compiled by the author based on [25]).

Hydration of the stratum corneum acts as a key regulator of tribological parameters in the “abrasive—skin” system because, by altering microrelief, elastic modulus, and true contact area, it shifts interaction from a regime dominated by superficial friction and brittle microcrack formation (typical of dry, rigid skin with low μ and a high propensity for stress concentration, overheating, and “overfiling”) to a viscoelastic regime of controlled plastic deformation and desquamation under moderate moisturization. In this state, μ may increase repeatedly (in some reports—by up to ~13-fold) due to softening and expansion of the contact area; this makes it possible to maintain effectiveness with softer abrasives and lower RPM, reduces the need for high compressive force, minimizes the risk of penetrating into viable tissues, and simultaneously decreases thermal load through improved heat dissipation and evaporative cooling.

CHAPTER III. CLINICAL PROTOCOLS AND INSTRUMENT MANAGEMENT

Based on the pathophysiological and physical analysis, this section formulates strict methodological guidance for performing the procedure. The foundational principle is a complete refusal of cutting instruments (scissors, skin nippers), because the risk of microtrauma and subsequent infection associated with their use in patients with diabetes is unacceptably high.

3.1. Selection of the Rotary Instrument (Bits)

Bit material and geometry represent one of the key regulators of both heat generation and the degree of invasiveness, because they determine the dominant mechanism of material removal (cutting, abrasive wear, or a combination), the micro-asperity contact pattern, and the rate of heat transfer out of the friction zone. For diabetes-associated skin changes (xerosis, rigidity, susceptibility to microfissures and delayed repair, as well as potential sensory insufficiency), the priority is minimization of the cutting component and prevention of local “thermal spikes” capable of triggering coagulative injury in the absence of timely pain signaling.

Carbide bits, by design and operating principle, are closer to micro-cutting tools: bladed flutes remove material as chips, creating high local stresses at the contact edge. When applied to cuticles and skin, such kinematics increase the likelihood of a linear defect spanning the full thickness of superficial layers with extension into the dermis—an outcome that, in diabetes, is associated with risk of prolonged inflammation and infection. An additional unfavorable factor is the high thermal conductivity and heat capacity of the metal body: the bit more rapidly accumulates and transfers heat to tissues, increasing thermal burden in the contact zone, particularly during continuous retention of the instrument on a single area [31]. For these reasons, the use of carbide bits on skin and cuticles in diabetes is regarded as unacceptable from the standpoint of preventing cuts and thermal trauma.

Ceramic bits are more rationally positioned primarily for removal of artificial material because their thermophysical properties are more favorable: lower thermal conductivity compared with metal reduces the rate of heat transfer and decreases the likelihood of abrupt local overheating during brief contact [32]. At the same time, ceramics provide a “softer” thermal contact with tissues during incidental touch, although mechanical injury remains possible if technique is violated. For added protection, selection of designs with a rounded tip is justified, as these reduce the risk of puncture or tearing during unintended contact with skin and lateral nail folds.

Diamond bits are generally considered the base tool for work on skin due to an abrasive rather than cutting mechanism of removal; however, in diabetes, grit size is decisive. Acceptable options are fine-grit variants (typically red marking, approximately 180–240 grit) and extra-fine variants (yellow marking), because they provide controlled desquamation of the stratum corneum while minimizing the depth of abrasive penetration [33]. Coarse grains (blue, green marking) increase the amplitude of micro-cuts and the probability of forming a net of microfissures in rigid, glycated skin, which elevates the risk of inflammation and secondary infection, and also requires greater pressure and is accompanied by more intense heat generation [33, 34]. Accordingly, grit limitation is not a cosmetic preference but an element of complication prevention driven by impaired mechanical tolerance and reparative insufficiency of diabetic tissues.

From a practical standpoint, bit selection in diabetes should be treated as part of a strategy to control parameters of Q(heat release) and microtraumatization: the higher the proportion of cutting and the higher the tool’s thermal conductivity, the smaller the tissue “safety margin” under errors in exposure, pressure, or speed. The safest profile is formed by fine-grit abrasives and geometry that excludes sharp peaks, combined with work modes that prevent prolonged stationary contact and provide the minimally sufficient mechanical load to remove only keratinized structures.

3.2. Regulation of Speed Modes (RPM and Torque)

In professional practice, there is a common belief that increasing rotational speed automatically yields a "cleaner" finish. For tissues with diabetes-associated changes of the feet and hands, this logic is pathogenetically unsafe: higher RPM increases the linear surface speed of the bit and, with it, the proportion of mechanical energy converted into heat within the contact zone. When xerosis, stratum corneum rigidity, and limited heat dissipation coexist, even brief fixation of the instrument on a single area can produce local temperature spikes that are clinically dangerous under reduced sensitivity.

Rotational ranges proposed within evidence-oriented protocols are designed to minimize thermal and mechanical risk while preserving the effectiveness of abrasive removal. For cuticle and pterygium processing, a range of 5,000–7,000 rpm is substantiated, at which a fine-grit diamond bit performs gentle polishing of softened tissue without meaningful overheating [35]. For delicate polishing of lateral nail folds, 7,000–10,000 rpm is considered appropriate, whereas coating removal is acceptable within 12,000–15,000 rpm, provided exposure is controlled and pressure that provokes "digging-in" of the abrasive into tissue is absent. Speeds above 20,000 rpm are viewed as justified primarily in systems with active water cooling (spray irrigation), which are more often implemented in pedicure solutions and comparatively rarely in manicure devices.

It is critical to recognize that RPM alone is not an independent marker of safety: thermal load is determined by the combination of speed, compressive force, duration of continuous contact, and abrasive grit. Increasing RPM while maintaining pressure and a fixed movement trajectory elevates the risk of thermal injury more strongly than a moderate speed increase accompanied by reduction of normal force and shortening of contact time. Therefore, “cleanliness” of processing in a clinically safe sense should be understood as controlled removal of superficial keratinized structures without creating occult microdefects and without overheating, rather than as maximization of RPM [36, 37].

Special attention should be given to torque, which effectively determines the device’s ability to maintain stable RPM under load. Low torque provokes a drop in speed when encountering denser areas, which is then compensated by increased pressure and prolonged contact; in mechanical terms, this increases N in the heat-generation equation and raises the likelihood of a burn or tissue tearing [37, 38]. A high torque (approximately not less than 2.5–3.0 N·cm) is considered practically meaningful, because it reduces the need for compressive effort, ensures predictable material removal, and decreases the probability of material “snagging.”

In diabetes, a rational strategy for mode selection involves not maximizing speed, but forming a stable “window of safety”: moderate RPM combined with sufficient torque, fine grit, minimal compressive force, and a dynamic technique without stationary bit fixation. This approach simultaneously reduces heat generation, lowers the risk of linear microtrauma in rigid skin, and increases reproducibility of outcomes—an especially important consideration in the setting of potential neuropathic loss of early sensory signaling of overheating and a limited reparative potential of tissues.

3.3. Chemical Safety and the Immune Response

Immunometabolic disturbances in diabetes mellitus create a state of functional imbalance between innate and adaptive immunity, which alters the pattern of cutaneous inflammatory reactions and increases the probability of a complicated course of contact dermatoses. In this setting, delayed-type hypersensitivity reactions (type IV) to components of nail coatings acquire special clinical relevance, because even a limited periungual lesion may be accompanied by barrier disruption, fissuring, and secondary microbial colonization. The most problematic sensitizer group in nail practice remains (meth)acrylates, which exhibit pronounced allergenic potential and the ability to penetrate during skin contact [39].

HEMA (2-hydroxyethyl methacrylate) belongs to low-molecular-weight monomers with high diffusivity, making it one of the leading allergens in gel-polish systems. In the presence of diabetes-associated dryness and microfissures, conditions for monomer penetration are amplified, and the risk of sensitization and clinical manifestation of allergic contact dermatitis increases. To reduce allergen burden, preference should be given to "HEMA-free" systems, because exclusion of a key sensitizer lowers the likelihood of persistent sensitization and recurrent inflammation. The clinical significance of dermatitis in diabetes extends beyond subjective pruritus: scratching and linear excoriations compromise barrier integrity and increase the risk of secondary bacterial infection, including colonization by *Staphylococcus aureus*, which is regarded as an additional factor aggravating the inflammatory process [21].

Acid primers represent a separate source of procedural risk. Containing methacrylic acid, they can induce chemical injury, particularly in the setting of a thinned, dehydrated nail plate and microdefects of the surface. For diabetic cohorts, restriction of such agents is substantiated: acid-free bonding systems (acid-free bond) are preferable, or primers may be avoided altogether in favor of a gentler mechanical surface preparation using soft, controlled buffing. This approach reduces the probability of chemical burn and decreases the cumulative exposure to potential sensitizers while preserving adhesion potential through optimization of plate microrelief.

Keratolytic removers require particularly strict assessment with respect to pH and mechanism of action. Alkaline products with $pH > 12$ can cause deep maceration, chemical burns, and pronounced barrier disruption—an effect that, in diabetes, is associated with a risk of prolonged inflammation and secondary infection. Therefore, the use of aggressive alkaline keratolytics in the cuticle zone should be excluded. Acceptable agents include urea-based preparations at concentrations up to 20%, which act primarily through moisturizing and keratoplastic mechanisms, reducing dryness and facilitating atraumatic removal of keratinized masses without chemical destruction of viable tissues. In this way, selection of "soft" chemical agents and reduction of allergen burden are not cosmetic nuances, but pathogenetically grounded measures for preventing complications in patients with diabetes.

3.4. Rationale and Technique of the "Wet" Method

On the basis of combined tribological and clinico-pathophysiological premises, the "wet" technique—including combined protocols using moisturizing agents—is considered a priority approach within a system for reducing thermal and mechanical risk. Its advantage is determined not only by evaporative heat removal and reduction of local temperature-spike amplitude, but also by shifting the stratum corneum into a more viscoelastic state, in which removal of keratinized structures proceeds more controllably and requires lower tool aggressiveness. Under conditions of diabetes-associated xerosis and reduced reparative potential, precisely the managed hydration of the working zone functions as a key factor in preventing microfissures, occult tears, and the subsequent inflammatory response.

The procedural algorithm is appropriately structured as a sequence of steps, each aimed at minimizing barrier injury and overheating. At the antisepsis stage, use of alcohol-free agents is substantiated, because ethanol and isopropanol intensify stratum corneum dehydration and may exacerbate xerosis, increasing the coefficient of friction and reducing tissue tolerance to mechanical impact. Preservation of the hydrolipid mantle and prevention of irritation are essential, particularly in the presence of microfissures and periungual inflammatory changes.

Next, brief softening of the cuticle is rational using foam express softeners based on urea at concentrations of 10–15% with an exposure time of 1–2 minutes. This range provides predominantly moisturizing and keratoplastic action without aggressive chemical destruction and leads to a reduction in the elastic modulus of the stratum corneum and an increase in its elasticity, making subsequent processing less traumatic [30]. Importantly, controlled hydration in this mode creates conditions for desquamation of superficial keratinized masses with minimal need for pressure and high RPM.

The hardware stage within a wet technique is optimally performed using fine-grit diamond bits at low speeds on the order of 5,000–7,000 rpm, which reduces linear contact speed and limits heat generation. In the presence of moisture, abrasive dust binds into a pasty mass, decreasing aerosolization of particles, stabilizing contact, and further improving heat dissipation through increased heat capacity of the surface layer. The shift from a “dry” dust cloud to a wet suspension also has hygienic relevance, because it reduces dispersion of fine particles capable of carrying microbial and allergenic components.

The final stage related to cuticle correction requires a fundamentally atraumatic approach: exclusively hardware smoothing (e.g., “ball” or “pear” attachments) or complete avoidance of cutting, with reliance on a European technique, is considered preferable. Use of scissors and other cutting instruments in this clinical setting is unsafe due to the increased risk of linear skin defects under potential sensory insufficiency and delayed repair. Thus, a wet protocol, combined with low-RPM abrasive processing and refusal from cutting techniques, forms a pathogenetically substantiated model for reducing diabetes-associated complications.

A comparative risk matrix of instrumentation is presented in Table 2.

Table 2. Comparative Risk Matrix for Instrumentation (compiled by the author based on

[33,35,39]).

Instrument	Risk level	Status for diabetes	Rationale (Pathophysiology)
Metal nippers	Extreme	PROHIBITED	Cut risk; barrier disruption; delayed healing.
Carbide bits	High	PROHIBITED	Aggressive cutting; rapid heating; risk of overfiling the nail plate.
Coarse abrasive (green/blue grit)	High	PROHIBITED	Microfissure “fraying”; portals of entry for infection.
Diamond bits (red/yellow, fine/extra-fine)	Low	PERMITTED	Polishing rather than cutting; controllable depth of impact.
Silicone polishers	Minimal	RECOMMENDED	Sealing of skin scales; polishing with minimal injury risk.

On the basis of the above, it can be stated that the “wet” method, under diabetes-associated xerosis and reduced reparative capacity, represents a pathogenetically grounded strategy for lowering complication risk, because it simultaneously reduces thermal load (through evaporative heat removal and increased heat capacity of the superficial layer) and shifts the stratum corneum into a viscoelastic state in which keratinized structures are removed more predictably and with less instrument aggressiveness. Practical implementation includes avoiding alcohol-based antisepsis to prevent additional dehydration; brief, gentle cuticle softening with urea-containing express agents at 10–15% (1–2 minutes) to reduce elastic modulus and facilitate controlled desquamation; e-file processing with fine-grit diamond bits at low rotational speeds (≈5,000–7,000 rpm) with formation of a moist paste that reduces overheating and aerosolization; and final correction according to an atraumatic principle (polishing with "ball/pear" attachments or a European technique without cutting). This approach is logically consistent with the risk matrix: cutting instruments, carbide bits, and coarse abrasives are unacceptable for diabetes, whereas "red/yellow" diamond bits and silicone polishers are preferable because they provide controllable depth and minimize barrier damage.

CHAPTER IV. PSYCHOSOCIAL INTEGRATION AND MARKET PROSPECTS

Chapter IV positions diabetes-aware aesthetic care as both a psychosocial rehabilitation resource and an emerging market niche: it argues that diabetes—especially when visible complications or wearable devices are present—can disrupt body image and reinforce “patient identity,” with body-image disturbance linked to poorer quality of life and depressive symptoms, so safe grooming of hands/feet functions as a compensatory stabilizer that restores everyday controllability, reduces “otherness,” and can indirectly support self-efficacy and adherence to preventive self-care; it frames outright refusal to serve clients “because of diabetes” as stigmatizing and countertherapeutic, whereas competent atraumatic protocols provide an experience of safe inclusion and psychological support; it then proposes a communication-and-screening model tailored to high diagnostic latency by shifting from blunt disease questions to a neutral “safety and care” script focused on functional risk markers (dryness, slow healing, reduced heat sensitivity, paresthesias) and, when neuropathy is suspected, augmenting self-report with visual symptom tools (e.g., pain-picture scales) to improve accuracy; finally, it links these clinical and ethical imperatives to market prospects, noting parallel growth in nail-care and diabetes-complication sectors and arguing that their intersection is catalyzing a “medical aesthetic” manicure/pedicure segment where standardized risk management, atraumatic technique selection, controlled e-file parameters, strict hygiene, and clear referral pathways become a competitive advantage—reducing complication-related legal/reputational risk while capturing a growing, trust-driven client base.

4.1. Body Image and Psychological Rehabilitation

Diabetes mellitus is often accompanied by disturbances in body image, especially when visible complications are present and when permanent use of medical devices is required, including continuous glucose monitoring sensors and insulin pumps [41]. This phenomenon has not only a psychological, but also a clinical–social dimension: a chronic disease shapes a stable “patient identity,” while an external marker of illness intensifies attention to bodily changes. Within White’s model, body-image disturbance is considered a factor statistically associated with depressive symptomatology and decreased quality of life, reflecting the systemic nature of diabetes’ influence on emotional functioning [40, 42].

Within this logic, the grooming of hands and feet acquires the meaning of a compensatory resource that supports a sense of “normality” and everyday controllability. Aesthetically acceptable hand appearance functions as a psychological stabilizer: it reduces the experience of “otherness,” lowers anxiety related to social evaluation, and supports maintenance of a positive bodily identity. At the same time, cosmetology and podology interventions performed with attention to diabetes-specific risks can become part of a broader behavioral pattern of self-support, indirectly influencing readiness for regular care, adherence to preventive recommendations, and control of complication risk factors.

Refusal of service on the basis of diagnosis (“I don’t work with diabetics”) should be interpreted as a stigmatizing practice, because it reinforces social marking of the disease and intensifies the experience of vulnerability. From a psychosocial perspective, this may amplify distress and support depressive cognitions associated with helplessness and social exclusion, directly contradicting the goals of quality-of-life maintenance in chronic illness. By contrast, competent service delivery within atraumatic protocols creates an experience of safe interaction with the service environment, supports self-esteem, and strengthens motivation for self-care as an achievable and controllable strategy.

The presence of empirical data indicating a positive effect of improved aesthetic appearance of hands and feet on the psychoemotional state of patients with chronic diseases underscores that aesthetic correction is not limited to a superficial "cosmetic" effect, but can serve as a meaningful component of psychological well-being and social adaptation [43, 44]. In the context of diabetes, this effect acquires additional clinical value, because reduced distress and strengthened self-efficacy are associated with more stable patterns of self-management and preventive behavior, making ethically and professionally organized service part of interdisciplinary patient support.

4.2. Effective Communication and Screening

The high latency of diabetes mellitus, in which a substantial proportion of cases remains undiagnosed, creates an objective clinical risk for nail service: potentially vulnerable clients may not report the condition not due to concealment, but due to absence of a diagnosis. For this reason, collecting information about factors that influence procedural safety is best structured as a standard component of a protocol aimed at preventing microtrauma, thermal injury, and complicated healing, rather than as an attempt to "verify a diagnosis." This logic is particularly justified given that undiagnosed cases are estimated at approximately 43% of the total population living with diabetes [3].

A direct, blunt question about diabetes can activate vigilance and defensive responses, reducing communication quality and response reliability. A more productive framework is a "safety and care" frame, where emphasis is shifted from disease to functional skin characteristics and tolerance to exposure. As a standardized script, a neutral formulation is appropriate: "To choose the safest and most comfortable technique, it is important to clarify skin features: are there pronounced dryness, slow healing of minor injuries, reduced sensitivity to heat, or unusual sensations (burning, tingling, numbness)? Are there any medical limitations related to blood sugar?" Such framing supports a partnership tone, reduces stigmatization, and at the same time allows identification of key markers of elevated risk [55, 56].

When a neuropathic component is suspected, questioning should be supplemented with visual tools, because verbalization of sensory phenomena can be difficult for some individuals: sensations may be perceived as "strange," may not fit familiar categories of pain, or may not be associated with trouble at all. Use of visual scales and image sets for symptom description (including the Pain Pictures toolkit) improves self-report accuracy and helps differentiate burning, tingling, numbness, and other modalities that carry different clinical implications for evaluating thermal and mechanical risks [45, 46].

4.3. Development Prospects for the Medical Manicure Market

The nail-care market demonstrates stable upward dynamics, reflecting a structural shift toward regular aesthetic and preventive practices. Estimates place the global nail products market in 2024 within the range of USD 24.5–25.6 billion, while long-term projections suggest growth to USD 41.9 billion by 2033 [48]. In parallel, the sector associated with management of diabetes complications is expanding, including the diabetic foot direction: the relevant market is estimated at approximately USD 9.5 billion in 2024 [50]. Such synchronous expansion reflects not a random coincidence of trends, but a broader logic of population aging, increasing chronic morbidity, and rising demands for quality of life.

At the intersection of these segments, an independent "medical aesthetic" niche is forming—medically oriented aesthetic manicure/pedicure, in which the aesthetic outcome is achieved through protocols that minimize trauma, thermal load, and infectious risk in vulnerable groups. From a clinical–organizational standpoint, this entails a practical institutionalization of risk management in salon practice: standardized collection of anamnestic markers, selection of atraumatic techniques, control of e-file parameters, appropriate referral pathways when complications are suspected, and strict adherence to sanitary requirements. This format reduces the probability of procedure-induced defects of skin and periungual tissues that, under diabetes-associated impairment of repair, may have disproportionately severe consequences [47, 54].

For salon businesses, implementation of specialized protocols becomes a source of competitive differentiation: trust is established among audiences that require safe and predictable care, repeat visits increase, and the client base becomes more stable. The economic rationale of the strategy manifests in access to a growing, less price-sensitive segment, as well as in reduction of reputational and legal risks associated with procedural complications. As a result, the "medical aesthetic" approach represents both an ethically grounded and financially viable development model in a saturated market with intensifying competition.

CONCLUSION

Safe manicure delivery for clients with diabetes mellitus represents an interdisciplinary technology that requires competencies substantially exceeding the scope of standard professional training. Clinically significant are knowledge of the pathophysiological consequences of non-enzymatic collagen glycation, neuropathy-driven reduction or loss of pain and tactile sensitivity, and the regularities of heat generation during e-file processing, because even brief local overheating and microtraumatization in this group are associated with increased risk of skin-barrier defects and infectious complications. The combination of these factors predetermines the need for a principled refusal of traumatic "dry" protocols and classic cutting techniques as potentially unsafe under diabetes-associated tissue vulnerability.

From a scientific standpoint, the most rational approach is implementation of a "wet," low-speed e-file method that suggests use of specialized abrasives and materials with a hypoallergenic profile. This approach makes it possible to control friction and heat-generation parameters, reduce the likelihood of microdamage, and simultaneously maintain the required quality of the aesthetic outcome, forming a reproducible balance between external effect and medical safety. Within this paradigm, the nail-service specialist is viewed not only as a performer of a cosmetic procedure, but also as a functionally significant link in the prevention of diabetic complications, while simultaneously contributing to maintenance of patients' psychosocial well-being.

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