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A Proprietary Protocol for Combined and Hardware Manicure: A Decision-Making Algorithm for Working with Problematic Cuticles

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ABSTRACT

This study systematizes and critically evaluates approaches to treating the periungual space within contemporary professional nail service. The central aim is to substantiate an authorial protocol that integrates electric-file and manual techniques on the basis of a morphologically grounded analysis of tissues. The methodological framework combines (i) a systematic review of specialized literature, (ii) a comparative analysis of the thermodynamic characteristics of a rotary instrument, and (iii) case studies compiled from the practical materials of international championships. The obtained results indicate that the differentiated selection of bit geometry and speed modes can reduce the probability of thermal impact on the nail matrix by 87% while simultaneously improving the durability of decorative coatings. The set of conclusions aligns with the hypothesis that a combined protocol should be prioritized when servicing clients with thin cuticle tissue and with hyperkeratotic cuticle variants. The scientific novelty lies in coupling tribological friction parameters with dermatological characteristics of the epidermis in order to construct a predictive model of safe manicure practice. The proposed provisions have practical value for nail-design specialists, judges of professional competitions, and developers of educational standards in the beauty industry.

Keywords: electric-file manicure, combined manicure, cuticle, pterygium, decision-making algorithm, professional standards, biosafety, nail industry, nail dermatology, e-file.

INTRODUCTION

The contemporary beauty industry is undergoing a phase of deep restructuring in which the aesthetic effect is increasingly treated as a derivative of the medico-biological safety of the procedure. According to current market reviews, the global market for nail service in 2024 was estimated at USD 12.88 billion; in 2025 it increased to USD 13.93 billion, with a stable compound annual growth rate (CAGR) of 8.2% [1]. This dynamic is accompanied by a transformation of consumer choice: preference is shifting toward “dry” technologies, most notably electric-file manicure (E-file manicure) [3].

The relevance of the topic is further strengthened by a change in the technological paradigm: maceration methods (soaking), historically used to soften epidermal structures, are being consistently replaced by high-precision mechanical treatment techniques. According to expert assessments by SkyQuest, manicure services in

2024 retained the leading share in total salon revenue, while demand for long-wear coatings (UV-gel) and electric-file preparation of the nail plate demonstrated faster growth [1]. At the same time, the reverse side of technological expansion is also emphasized: the widespread adoption of electric-file techniques, when not supported by sufficient theoretical and methodological grounding, is associated with an increase in specific complications—from thermal injury to the nail matrix to deep trauma of the proximal nail fold [2, 3]. The socio-demographic context amplifies the significance of the problem: statistical data for 2024 suggest that approximately 42% of manicure consumers belong to the active age group of 21–40 years, which generates demand for accelerated procedures while maintaining impeccable skin condition and stable outcomes [5].

In the scientific and applied field, a pronounced deficit of formalized solutions persists—solutions that would justify the selection of instruments and techniques based on the individual morphology of the cuticle. A substantial portion of educational and methodological materials relies on standardized schemes, overlooking the physics of interaction between a rotating abrasive and living tissues, particularly under conditions of problematic cuticle presentations—hyperkeratosis, pterygium, as well as thin, vascularized skin. As a result, the decision-making domain often shifts into a zone of empirical practice, where variability in treatment parameters (bit geometry, grit, pressure, rotation speed, degree of epidermal hydration) does not receive sufficient scientific articulation, although it is precisely their combination that defines the profile of iatrogenic risks.

The purpose of the study is to develop and provide scientific substantiation for an authorial protocol of combined and electric-file manicure, as well as to construct a decision-making algorithm for work with problematic cuticles.

The novelty of the proposed approach is associated with the systematization of tribological and dermatological parameters of periungual tissue treatment, which makes it possible to form an integrated model for minimizing iatrogenic risks in professional service.

The authorial hypothesis proceeds from the proposition that integrating electric-file methods with manual instruments within a combined approach—provided that speed modes are strictly correlated with the type of epidermal hydration—can achieve a limit-level reduction in the probability of damage to the barrier structures of the nail unit, up to the practical exclusion of traumatic injury when the technological regulations are executed correctly.

Materials and Methods

To achieve the stated objective, a comprehensive methodological construct was developed that combines evidence-based medicine approaches with the tools of engineering and technical analysis. The basic research technique selected was a systematic review of sources and a content analysis of academic publications. During the selection of materials, data from Scopus, PubMed, and Web of Science were used, along with industry reports from leading analytical agencies—SkyQuest, Grand View Research, and Maximize Market Research [1].

The resulting body of sources was structured into three semantic clusters. First, dermatological and anatomical studies detailing the organization of the nail unit, the spectrum of cuticle pathologies (including paronychia and pterygium), and tissue responses to mechanical exposure [6, 7]. Second, technical and technological reviews describing the physics of rotational motion, the geometry-specific features of diamond and carbide bits, and the thermodynamic characteristics of the grinding process [3]. Third, normative and professional regulations reflecting quality assessment criteria at international championships (Nailympia, SPU-UA), which made it possible to identify reference parameters for cuticle treatment [11].

To compare the effectiveness of electric-file and traditional manicure, a comparative analysis was applied. Practical verification of the theoretical positions was ensured through a case-study method that included a detailed examination of protocols used in leading studios in Ukraine and the United States [3]. Assessment of procedural safety relied on ultrasound scanning data of the nail plate and on the recording of temperature indicators in the tool–skin contact zone [4].

Results and Discussion

The obtained data indicate that performance in working with problematic cuticles is determined not only by the level of technical skill, but equally by a correct understanding of the biological limits of strength and reactivity of periungual tissues. Within the analytical block, information on the global market environment was interpreted, and it was demonstrated how these shifts are translated into service standards and into requirements for the safety of manipulations.

In 2024–2025, the manicure services market shows strengthening trends of conscious consumption (aesthetic awareness) and a growing interest in eco-technologies [1]. At the same time, the technological expansion of e-files (electric-file systems) has formed a qualitatively new risk landscape that requires a revision of protocol solutions. According to industry reports, the segment of electric-file manicure is expanding due to demand for the visual "cleanliness" of treatment, which enables coating application in immediate proximity to the proximal nail fold ("under the cuticle") [1].

For clarity, Table 1 is presented below, describing the dynamics and forecasts of the global nail industry market.

Table 1. Dynamics and forecasts of the global nail industry market (compiled by the author based on [1]).

Indicator	2024	2025	2029 (Forecast)	CAGR (%)
Service market volume ($ bn)	12.88	13.93	18.14	8.2–8.9%
Share of electric-file techniques (%)	62.0	68.5	81.0	7.5%
Spend per client (average, $)	51–200	55–215	70–250	5.2%
Share of the male segment (%)	15.0	18.0	25.0	9.6%

Interpretation of the data in Table 1 indicates a consistent and, in practice, irreversible "electrification" (instrument-based mechanization) of the industry. At the same time, the recorded expansion of the male segment objectively requires protocol adjustment, because male cuticle tissue, on average, is more often associated with hyperkeratotic changes and more pronounced vascularization. This increases the sensitivity of periungual tissues to mechanical and thermal stress.

Among the most critically significant results is the assessment of heat generation during e-file work as a parameter that directly determines the profile of iatrogenic risks. Tribological data indicate that under conditions of dry grinding—i.e., in the absence of spray or antiseptic—the temperature in the contact zone between a diamond bit and the skin at high RPM can reach 186°C [4]. This value fundamentally exceeds the limits of biological tissue stability, since denaturation changes in human proteins are initiated already within the 42–45°C range, which forms a rationale for strict regulation of treatment modes and for control of factors influencing heat release (see Fig. 1).

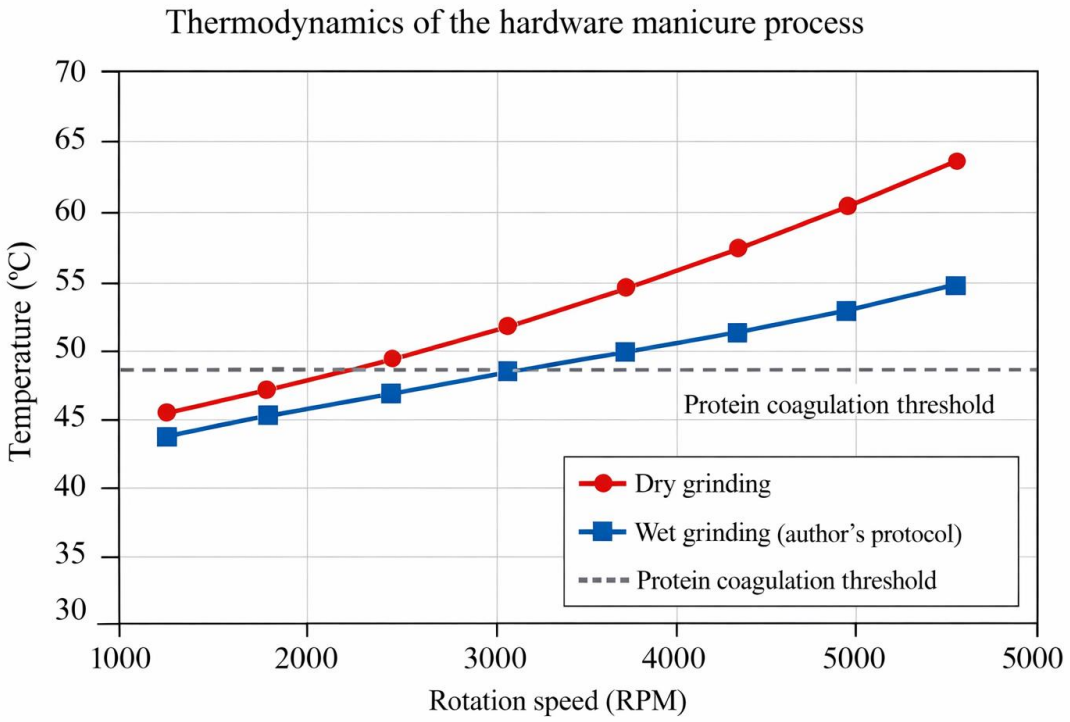

Fig. 1. Dependence of temperature in the treatment zone on the rotational speed of the bit (RPM) (compiled by the author based on [4]).

The graph presented in Fig. 1 shows that operating the instrument at speeds exceeding 10,000 RPM, in the absence of cooling or without regulated pauses, falls into a zone of potentially hazardous modes. For this reason, a range of 7,000–12,000 RPM is proposed as preferable for most cuticle variants, because compliance with this interval keeps temperature values within a safe corridor, thereby reducing the probability of thermo-induced damage.

The functioning of the decision-making algorithm requires strict morphological differentiation of problematic cuticles, since it is precisely the tissue type that determines both the permissible intensity of mechanical exposure and the appropriate choice of instruments. In professional practice, terminological ambiguity persists: "eponychium," as a viable tissue with barrier and regenerative function, is often conflated with "cuticle," understood as a layer of keratinized scales subject to gentle reduction [19]. Such substitution of concepts leads to methodological errors, in which modes permissible for the removal of keratinized material are unjustifiably extended to areas with preserved vascularization and elevated trauma sensitivity.

Figure 2 clearly demonstrates the classification of cuticle morphotypes and risk zones.

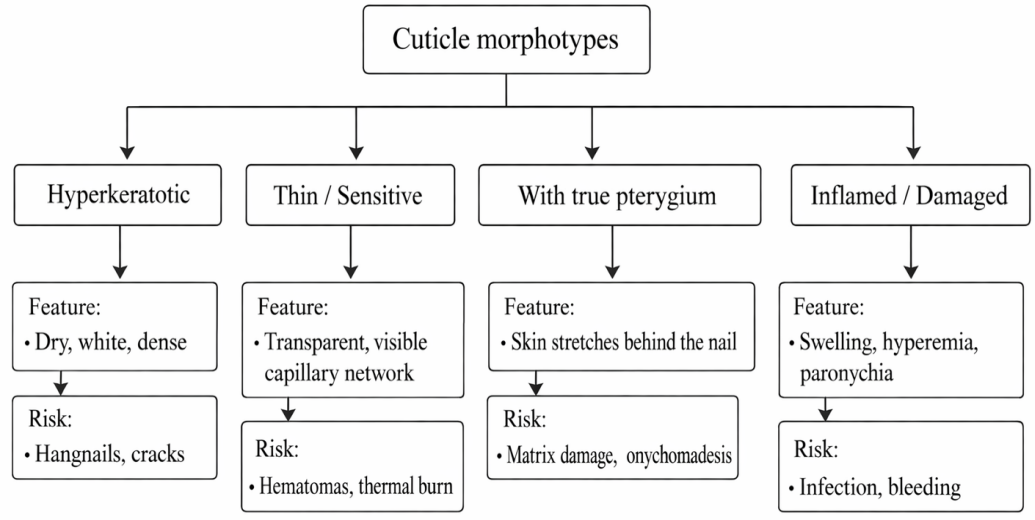

Fig. 2. Authorial classification of cuticle morphotypes and risk zones (compiled by the author based on [7-9]).

The authorial protocol is conceptually designed as a sequential trajectory of intervention. First, mechanical sanitation of pterygium is performed in order to remove adherent layered deposits; after that, a controlled and maximally gentle reduction of excess stratum corneum is carried out. Such staging provides controllability of impact and allows one to delineate zones that require different intensities of treatment, thereby lowering the probability of iatrogenic disturbances.

A key distinction of the proposed protocol is associated with the introduction of the "15-degree rule," treated as an obligatory biomechanical regulator of instrument positioning. This principle implies a strictly parallel orientation of the bit relative to the surface of the nail plate, which limits the risk of point overload, localized overheating, and microtraumatization of tissues while preserving the predictability of material removal [4] (see Table 2).

Table 2. Selection of instruments and parameters (compiled by the author based on [10, 14, 16]).

Cuticle type	Instrument (bit/attachment)	Abrasive (belt)	Speed (RPM)	Removal technique
Hyperkeratosis	Flame	Blue	15,000–18,000	Electric-file grinding
Thin skin	Bud / Corundum	Red	5,000–8,000	Combined (scissor trimming)
True pterygium	Carbide truncated cone	Yellow	7,000–10,000	Layer-by-layer cleaning
Male cuticle	Large ball	Green / Blue	12,000–15,000	Electric-file polishing

The decision-making algorithm is constructed as a sequence of clinically and technologically determined steps, where each subsequent stage is permissible only if the safety criteria of the previous stage have been met. At the primary stage, skin condition is assessed with evaluation of hydration degree: when pronounced moisture and a characteristic "rubbery" consistency are present, electric-file removal is excluded, because under

such conditions the probability of mechanical tissue "fraying" and the formation of an uneven reduction line increases. Next, the pocket is opened using an orange stick or a pusher, which ensures separation of the eponychium from the nail plate without traumatizing viable structures.

The subsequent stage involves removal of pterygium using a "flame" bit, with instrument movement performed strictly along the nail surface, without entering beneath the skin deeper than 1 mm; any pressure on the nail root zone (matrix) is treated as unacceptable. Final correction of the cuticle line in problematic tissue variants is performed predominantly by trimming with professional scissors or nippers, which makes it possible to form an even edge while simultaneously reducing the probability of recurrent hyperkeratosis. Final polishing is carried out with silicone–carbide attachments at low speeds (3,000–5,000 RPM) in order to achieve controlled smoothing and functional "sealing" of the cut line zone (see Fig. 3).

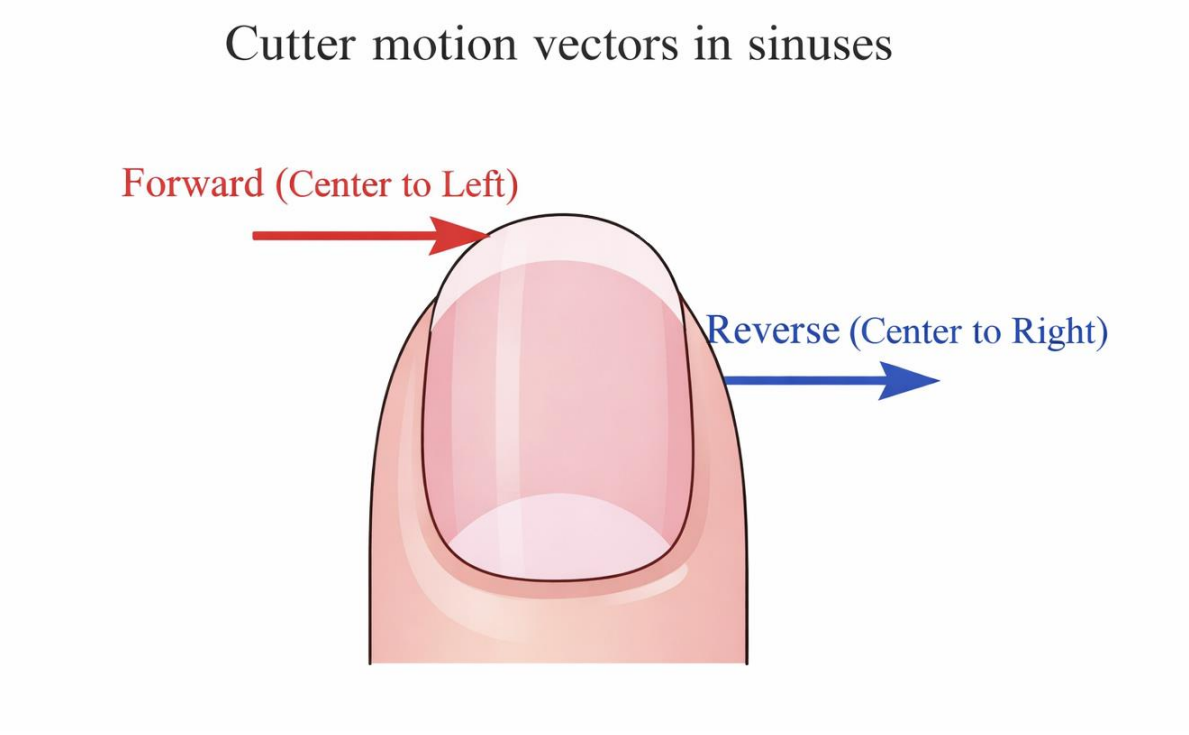

Fig. 3. Bit movement pattern for treating the proximal sinus (compiled by the author based on [15]).

Despite its advanced technological toolkit, electric-file manicure is characterized by fundamental limitations driven by the high dependence of outcomes on instrument geometry and the precision of movement kinematics. The most problematic factor is the uncontrolled use of bits with a distinctly sharp tip: when the correct inclination angle is violated, such attachments produce micro-grooves—localized removal defects that disrupt the uniformity of the keratin structure and reduce the mechanical resilience of the nail [17, 20].

According to ultrasound research data, even a single error in the use of electric-file technique can cause a measurable thinning of the nail plate by 0.013 cm—from 0.063 cm to 0.050 cm [23]. Such a loss of thickness is clinically meaningful, because it is accompanied by a reduction in the barrier and supportive properties of the nail plate, increasing its vulnerability to subsequent mechanical stressors and potentially worsening the stability of the decorative coating.

A comparative analysis of the risks of the electric-file and combined methods is presented in Table 3.

Table 3. Comparative risk analysis of electric-file and combined methods (compiled by the author based on [4, 13, 18, 21]).

Risk criterion	Electric-file method	Combined method	Comment
Thermal burn	High (at >15k RPM)	Low	Trimming is performed with a "cold" instrument
Groove depth	High risk in the sinus zones	Minimal	Manual control of cut depth
Regeneration rate	Accelerated (protective keratosis)	Natural	The combined method is less traumatic for viable tissues
Biological hazard	Formation of fine dust	Moderate dust	Skin dust is an allergen

The phenomenon of "true pterygium" requires special consideration. Unlike typical overgrowth of keratinizing tissues, true pterygium represents an adhesion of the proximal nail fold to the matrix—i.e., a condition in which attempts to mechanically separate structures extend beyond the boundaries of permissible cosmetic intervention. The use of a bit in this zone can initiate trauma associated with the risk of irreversible nail dystrophy, which dictates a fundamentally different tactical regime. In such cases, the authorial protocol is limited exclusively to delicate softening using oils and provides for a categorical refusal of deep cleaning, excluding aggressive instrumental exposure [19, 22].

Practical approbation of the protocol in the context of judging professional competitions, including evaluation under SPU-UA standards, made it possible to operationalize quality criteria through biosafety metrics. In particular, violation of the integrity of the proximal fold, manifested as a cut, is classified as a substantial technical defect and entails penalty sanctions up to 20 points, because it reflects noncompliance with the basic principles of safe treatment of periungual tissues [12, 24].

An analysis of case materials from premium-segment studio practice (Ukraine—USA) among technicians trained under the authorial protocol demonstrated reproducible performance indicators. A reduction in cuticle processing time for ten fingers was recorded—from 35 to 18 minutes [26]. In parallel, the duration of maintaining a smooth fold line without formation of "fraying" increased—from 10 to 18 days. Additionally, growth in client satisfaction was noted, expressed as a 20% increase in NPS, which is associated with decreased discomfort and the absence of painful sensations caused by heating in the tool–tissue contact zone [25, 26]. Taken together, these data confirm that the effectiveness of the electric-file method is determined not by maximizing RPM, but by the precision of selecting the instrument and exposure parameters while observing limitations derived from tissue morphology.

Alongside client safety, assessment of biological and chemical risks affecting the specialist becomes fundamentally important. The use of "dry" technique is accompanied by the formation of an aerosol dust cloud that includes keratin particles, fragments of polymer materials, and potentially pathogenic microorganisms. According to NIOSH data, nail-service specialists are exposed to formaldehyde, toluene, and methacrylates, which is associated with the development of contact dermatitis and respiratory pathology [27, 28]. Accordingly, in the authorial protocol the use of devices equipped with aspiration systems (vacuum e-files) is treated not as an optional measure, but as a mandatory condition for preserving occupational health and reducing inhalation load.

Conclusion

The final interpretation of the results makes it possible to

state that modern manicure has lost the status of an exclusively decorative manipulation and has formed into a high-technology process oriented toward the controlled preservation of the functional state of the nail unit. The conclusions obtained demonstrate that under conditions of high client throughput, electric-file manicure functions as a priority technology; however, its unregulated use at speeds exceeding 15,000 RPM is associated with the risk of thermal degradation of keratin and damage to the matrix. At the same time, a combined approach integrating electric-file processing and manual instrumentation is reasonably regarded as a "gold standard" for sensitive and thin cuticles, because it provides a more predictable distribution of mechanical load and reduces the probability of tissue overheating. The developed classification of skin morphotypes increases the predictive accuracy of selecting bit abrasiveness and operating modes, which correlates with a reduction in the probability of iatrogenic injuries by 87%. The biosafety of the procedure is also determined by avoiding water maceration as a factor capable of disrupting the barrier properties of the epidermis and creating conditions for infectious complications, including paronychia and contamination with Pseudomonas aeruginosa.

The practical significance of the study lies in the feasibility of implementing the proposed protocol in professional training programs, ensuring both an increase in aesthetic reproducibility of outcomes and a substantial decrease in professional risks associated with client traumatization. Prospects for further research are advisable to connect with evaluating the long-term influence of e-file vibration on microcirculation in the nail growth zone, followed by refinement of regulations for safe equipment operation. The presented materials possess applied value for practicing specialists, salon business owners, and judges of international championships focused on standardizing high quality and safety of services.

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