Universal Library of Medical and Health Sciences Methodological Manual

ISSN: 3064-6545 | Volume 3, Issue 4

Open Access | PP: 78-91

DOI: https://doi.org/10.70315/uloap.ulmhs.2025.0304012

Scar Camouflage and Halo Reconstruction: Expanding the Possibilities of Permanent Makeup

Anzhela Voskanian

Permanent Makeup Artist. PMU JANE SYAN, Los Angeles, USA.

Abstract

Within the scope of this work, a study was conducted on paramedical dermopigmentation, considered as an integrative tool of aesthetic rehabilitation for cicatricial deformities of the skin and defects of the nipple–areolar complex (NAC). The presentation is based on an interdisciplinary synthesis of histological patterns, biophysical principles, and clinical and practical observations, which makes it possible to substantiate a shift in emphasis from a decorative understanding of permanent makeup toward a reconstructive concept. The study demonstrates the specificity of pigment behavior in fibrotically altered tissues: the mechanisms of its retention are analyzed in detail with consideration of the macrophage renewal cycle, as well as the influence of optical light-scattering phenomena in anisotropically organized collagen structures that determine the perceived density and tone of pigmentation. A substantial part of the work is devoted to the author's protocols of digital micropigmentation, the application of which ensured a 30% reduction in procedure duration while maintaining high reproducibility of the result and achieving a satisfaction index of 98% (n=500+), which received international recognition marked by the award of the Grand Prix. Current statistical data on the market for 2024–2025 are presented, demonstrating an exponential growth dynamic of the medical tattooing segment with an estimated CAGR of 9–11%. The publication is addressed to plastic surgeons, dermatologists, and specialists in aesthetic medicine and offers evidence-based algorithms for the management of patients with post-traumatic and postoperative defects.

Keywords: *Paramedical Dermopigmentation, Scar Camouflage, 3D Reconstruction of the NAC, Macrophage Pigment Retention, Optics of Scar Tissue, REACH Pigments, Digital Micropigmentation, Patient-Oriented Outcomes.*

CONTENTS

Citation: Anzhela Voskanian, Scar Camouflage and Halo Reconstruction: Expanding the Possibilities of Permanent Makeup", Universal Library of Medical and Health Sciences, 2025; 3(4): 78-91. DOI: https://doi.org/10.70315/uloap.ulmhs.2025.0304012.

INTRODUCTION

Aesthetic medicine of the 21st century demonstrates a pronounced paradigm shift: priority is gradually moving from purely decorative interventions toward technologies focused on restoring an integral body image and supporting psychoemotional rehabilitation. Within the framework of this shift, dermopigmentation (medical tattooing) loses the status of an exclusively cosmetology procedure and is regarded as a significant adjuvant method that complements reconstructive surgery and dermatological practice. Cicatricial deformities formed after injuries, burns, and surgical interventions, including mastectomy, represent not only a visual defect but also a factor capable of intensifying psychosocial maladaptation. Loss of the nipple–areolar complex (NAC) in the treatment of breast cancer is often experienced as a symbolic loss of femininity and bodily identity, which актуализирует the need for максимально accurate methods of visual reconstruction [1]. Classical approaches, including surgical nipple formation using local flaps, are associated with the risk of ischemic complications and necrosis, a gradual decrease in projection due to tissue remodeling, as well as the appearance of additional scars [3]. Against this background, 3D micropigmentation demonstrates a favorable balance between effectiveness and invasiveness, ensuring the durability of the aesthetic result with minimal травматization [4].

Economic and statistical data for 2024–2025 reflect a growing interest in medical tattooing as an independent field and as a component of comprehensive rehabilitation. The global scar treatment market volume in 2024 was estimated at USD 22.56 billion, and the forecast for 2034 indicates an increase to USD 64.06 billion with a compound annual growth rate (CAGR) of 11.0% [5]. The permanent makeup segment is also characterized by устойчивой positive dynamics: from USD 152.4 million in 2024 to a projected USD 277.8 million by 2032 [6]. The most illustrative changes are observed in breast reconstruction: retrospective data for 2007–2021 record a statistically significant increase in the proportion of patients choosing NAC restoration under the model of tattooing only, reaching 16.7% and maintaining a trend toward further growth, which is accompanied by a decrease in the demand for combined surgical strategies [4]. This is consistent with observations that 51.4% of patients after temporary pigmentation consider permanent tattooing as the preferred long-term solution [3].

The aim is to develop and provide evidence-based substantiation of existing algorithms for scar camouflage and reconstruction of the nipple–areolar complex by means of permanent makeup, ensuring predictable pigment retention, safety, and a high level of patient satisfaction.

Scientific novelty is determined by a comprehensive analysis of the interaction of pigment with pathologically altered tissues. Within a single study, the biophysical features of pigment introduction into scar tissue are systematically considered, taking into account the remodeled collagen architecture and the specifics of the immune response, primarily macrophage clearance, which affects the long-term preservation of the result.

The author's hypothesis is formulated as follows: implementation of the author's device-based pixel micropigmentation protocols, based on the principles of minimal травматization and coloristic correction of optical distortions of scar tissue, makes it possible to reliably increase pigment engraftment under conditions of fibrosis, reduce the duration of the procedure, and ensure a higher level of patient satisfaction compared with traditional manual and dense filling techniques.

CHAPTER 1. THEORETICAL FOUNDATIONS OF DERMOPIGMENTATION: FROM HISTOLOGY TO BIOPHYSICS

Within this chapter, the scientific basis determining the predictability and safety of medical dermopigmentation will be consistently examined: from the histological structure of intact skin and the pathomorphology of scar tissue (collagen architectonics, anisotropy and matrix rigidity, loss of appendages, changes in the epidermal–dermal junction and scar optics influencing the therapeutic window with respect to depth), through the immunobiological mechanisms of pigment retention within the framework of the macrophage theory (the capture–release–recapture cycle, the role of particle properties and the specifics of scar microcirculation/lymphatic drainage), to color science and pigment chemistry under the regulatory conditions of EU REACH, including differences between organic and inorganic systems in opacity, dispersity, and fading trajectories, as well as the practical consequences of reformulations of compositions (carriers, rheology, suspension stability) for clinical shade planning, material selection, and protocol standardization.

Skin Structure and Pathomorphology of Scar Tissue

Understanding the histological organization of skin and scar tissue is a key prerequisite for predictable dermopigmentation. Intact dermis functions as a highly organized biomechanical composite, where collagen fibers predominantly of types I and III, elastin, and an amorphous ground substance form a spatial network with multidirectional (pseudochaotic) interweaving of the woven-basket type. Such architectonics ensures isotropic distribution of loads, combining strength with reversible deformation and maintaining a stable optical environment for the visual perception of pigment [7].

Scar tissue forms as a result of reparative regeneration and is characterized by a fundamentally different microarchitecture of the extracellular matrix. Normotrophic and hypertrophic scars are characterized by pronounced anisotropy: collagen bundles are oriented predominantly parallel to the epidermal surface, reflecting the effect of mechanical tension during the healing and remodeling phase. The ordered packing is accompanied by increased matrix density and rigidity, forming tissue with increased mechanical resistance to

needle penetration and a narrower therapeutic window in terms of pigment implantation depth [8].

Structural and functional insufficiency of scar tissue is also manifested by reduction of skin appendages and remodeling of the epidermal–dermal junction. The absence of hair follicles, sebaceous and sweat glands is combined with smoothing of the boundary between the epidermis and dermis (loss of dermal papillae), which reduces the mechanical coupling of the layers and changes the pattern of light scattering. These features not only affect the stability of pigment fixation in the tissue but also modify the visual assessment of shade due to different surface optics of the scar [8].

To translate the morphological differences between skin and scar into applied protocol parameters, let us summarize the key features in a comparative table with clinical implications for dermopigmentation (see table 1).

Table 1. Intact skin and scar tissue: morphology, optics, and practical implications (compiled by the author based on [7, 8]).

Parameter	Intact skin	Scar tissue	Practical significance
Collagen architectonics	multidirectional network	parallel bundles (anisotropy)	higher needle resistance; narrower depth window
Matrix rigidity	lower	higher	higher risk of uneven pigment distribution
Skin appendages	preserved	reduced/absent	healing and reactivity change
Epidermal-dermal junction	pronounced papillae	smoothed	worse interlayer adhesion, higher requirements for depth
Hydration/ground substance	more uniform	more heterogeneous	diffusion/fixation of pigment is more variable
Optics (scattering)	more stable	higher scattering	the hue often appears visually cooler at the same dose

The cellular composition of a scar changes dynamically as it matures. In active, functioning scars, the proportion of myofibroblasts with expression of alpha smooth muscle actin (α-SMA) is increased, maintaining contractility and internal tissue tension; as maturity progresses, cellularity decreases, however, high density and relative paucity of the matrix in the aqueous phase preserve a tendency toward rigidity. This biology determines heterogeneity of resistance during pigment introduction and variability of its distribution within the same scar under an outwardly identical technique [9].

Additional importance is attributed to remodeling of the ground substance of the extracellular matrix: changes in the ratio of proteoglycans and glycosaminoglycans, as well as a decrease in hydration uniformity, create conditions for different diffusion of soluble pigment fractions and for more pronounced point fixation of particles in dense collagen domains. In parallel, changes in microcirculation and tissue oxygenation are possible, which affects post-procedural reactivity and the rate of remodeling, and, consequently, the long-term stability of the visual result.

The clinical consequences of the described differences manifest at the level of equipment selection and color prediction. Dense parallel packing of collagen requires the use of systems with high torque and a rational selection of needles, allowing tissue resistance to be overcome without excessive traumatization and without an uncontrolled depth drop. Optical heterogeneity of the scar and pronounced light scattering (including of the Tyndall-effect type) can lead to the pigment introduced at a standard depth being visually perceived as cooler (blue-gray) compared with healthy skin, which requires consideration in color planning and in stratification of the risk of an undesirable undertone [11].

Mechanisms of Pigment Retention: The Macrophage Theory

For a long period, the prevailing view was that pigment particles are retained in the dermis predominantly passively, being fixed due to mechanical trapping within the collagen framework. However, data from recent years have substantially adjusted this concept, showing that the persistence of dermopigmentation is determined not so much by inert immobilization of the colorant as by the dynamic involvement of innate immunity and tissue cellular renewal.

After pigment is introduced into tissues, an aseptic inflammatory reaction develops, initiating phagocytosis. Dermal macrophages recognize the particles as foreign material and actively engulf them. Most inorganic and a significant proportion of organic pigments prove to be biochemically resistant to lysosomal degradation, as a result of which they accumulate in the cytoplasm of phagocytes and remain there for a long time [12]. This fact is of fundamental importance: the container for the pigment becomes the cell, rather than only the interfibrillar spaces of the matrix.

The stability of the visual effect is ensured by the fact that macrophages overloaded with particles exhibit reduced migratory activity and remain localized within the dermis for an extended period. In this case, pigment retention acquires the character of a maintained equilibrium: as the pigment-laden macrophages undergo natural aging and apoptosis, the colorant is released into the extracellular environment, but almost immediately undergoes reuptake by neighboring macrophages or by monocytes recruited from the vascular

bed [14]. Thus, the durability of coloration is explained by the capture–release–recapture cycle, in which the key link is the continuous turnover of cells of the mononuclear phagocyte system, rather than static preservation of pigment in the tissue.

For protocol standardization, it is important to understand which physicochemical characteristics of the pigment and which features of scar tissue strengthen/weaken color retention; therefore, will reduce the determinants of retention to controllable factors (see table 2).

Table 2. Macrophage-mediated pigment retention: key factors and clinical effects (compiled by the author based on [12, 14]).

Factor	What exactly changes	How it will manifest as a result	Practical takeaway for the practitioner
Particle size	small vs large	rate of cellular turnover of pigment; risk of migration	avoid dust and unstable dispersion
Aggregation	single particles vs conglomerates	mottling, focal hypersaturation	layering, minimal passes
Surface/charge	protein adsorption corona	macrophage recognition changes	same color ≠ same durability
Scar microcirculation	capillaries/lymphatic drainage reduced	more variable shade stabilization	fractionated sessions + healing monitoring
Fibrosis density	matrix compartments	less washout, but greater heterogeneity	choose pixel/pointillism instead of solid fill

The kinetics of this cycle are influenced by the physicochemical characteristics of the dye: particle size and shape, surface charge, degree of aggregation, as well as their distribution within the intercellular matrix. Smaller fractions and readily dispersible aggregates are capable of being incorporated into cellular turnover more rapidly and potentially redistributed more actively, whereas large conglomerates are more often fixed locally and create pronounced heterogeneity of deposition. In parallel, the protein corona that forms on the surface of particles upon contact with tissue fluids is important: it modifies the recognition of the pigment by innate immune cells and may shift the balance toward more prolonged intracellular retention or more intensive recruitment of new phagocytes.

Under conditions of scar tissue, the described immunobiological mechanism often undergoes changes due to remodeling of the vascular and lymphatic bed. Impairment of microcirculation, reduction of the capillary network, and restructuring of lymphatic drainage limit monocyte influx and reduce the efficiency of cellular renewal of the pigment depot, which may manifest as delayed stabilization of the shade and greater variability of the result over time [15]. At the same time, the dense fibrotic scar matrix can serve as a mechanical barrier: compartmentalization of the intercellular space and high collagen density promote local encapsulation of particles and hinder their passive movement, which potentially reduces the likelihood of pigment washout but increases the risk of uneven distribution and optical heterogeneity of the staining zone [15].

An additional factor is the specific cellular ecology of the scar. Active scars are characterized by persistent signals of matrix remodeling and mechanical tension that maintain the functional activity of myofibroblasts and alter the profile of cytokines and growth factors. Such an environment can shift macrophage polarization and change the ratio of resident and recruited phagocytes, which is reflected in the rate of pigment recapture after cell death and in the degree of its intratissue dispersion. In mature scars, by contrast, with reduced cellularity and a dense extracellular matrix, deposition may become more static, but less predictable in terms of depth and lateral distribution, because microchannels and matrix compartments form unequal conditions for penetration and subsequent fixation of particles.

Colorimetry and Pigment Chemistry in the REACH Era

The selection of a pigment for medical camouflage is a multifactorial task in which safety, long-term colorimetric stability, and covering power must be considered as interrelated parameters of a single system. The clinical outcome is determined not only by the initial shade, but also by the behavior of the pigment suspension in the tissue environment, including the nature of particle dispersion, their interaction with cells of the mononuclear phagocyte system, as well as optical effects обусловленные by scattering and absorption of light in the dermis and in the scar-altered matrix.

Inorganic pigments are traditionally formulated on the basis of iron oxides, titanium dioxide, and, in some cases, chromium oxide. This group is characterized by larger particles, high opacity, and, as a rule, lower sensitizing activity. In practical terms, this is manifested in obtaining earthy, physiologic tones that are well aligned with the tasks of camouflage and reconstruction of the areolar complex. An important advantage is considered to be a predictable fading trajectory: a gradual decrease in saturation with a tendency to preserve a warm undertone is perceived clinically as more favorable and aesthetically more stable [16]. A limitation of inorganic systems is often lower visual brightness and the need for more careful layer-by-layer construction of the coverage, because high opacity requires careful dosing to prevent a chalky film effect.

Organic pigments, represented by synthetic carbon-containing compounds (including azo components and

phthalocyanines), are usually characterized by a smaller particle size and high color intensity with relative layer transparency. These properties facilitate implantation and can provide long-term preservation of saturation; however, precisely the small dispersity increases the likelihood of lateral redistribution under conditions of a loose or heterogeneous matrix, which clinically manifests as smearing and reduced sharpness of borders. An additional risk is associated with differential fading of component fractions: with more stable black-blue constituents and relative vulnerability of red-yellow shades, the hue may shift into an undesirable gray-violet spectrum, especially in areas with pronounced light scattering [18]. Thus, the high brightness of organic systems is not equivalent to high predictability of the result in the long-term perspective.

In the context of scar tissue, the choice between opacity and transparency acquires particular clinical significance. Increased light scattering, heterogeneous density of the collagen matrix, and variability of the microrelief create conditions under which the same pigment formula can produce different visual perception depending on the depth and uniformity of deposition. When using highly opaque compositions based on titanium dioxide, the risk of optical powderiness and a cold, ashen impression increases with minimal error in colorimetric balance; conversely, excessively transparent organic systems can enhance the visibility of underlying vascular or fibrotic elements, reducing the effectiveness of camouflage. Therefore, the appropriateness of combined approaches (managing the ratio of opaque and transparent components, building thin layers with controlled saturation) is determined precisely by the tissue optical conditions, and not only by the catalog shade of the pigment.

The regulatory environment of the European Union in 2024–2025 has become one of the key factors determining the availability and composition of pigment systems. The introduction of restrictions within the framework of EU REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals), since 2022 and implemented in stages with the full entry into force of bans in 2023–2024, has led to a substantial transformation of the market and the need to revise familiar formulas. Thousands of substances fell under the restrictions, which entailed the replacement of individual components and changes in formulations even in previously stable product lines [19]. In particular, Pigment Blue 15:3 and Pigment Green 7 were excluded from the permitted set due to a lack of safety data and presumed risks, despite the absence of direct confirmation of carcinogenicity in available materials [19].

For clarity, below in Figure 1 a timeline of the implementation of REACH restrictions will be presented and we will show how regulatory changes are transformed into technological and clinical consequences.

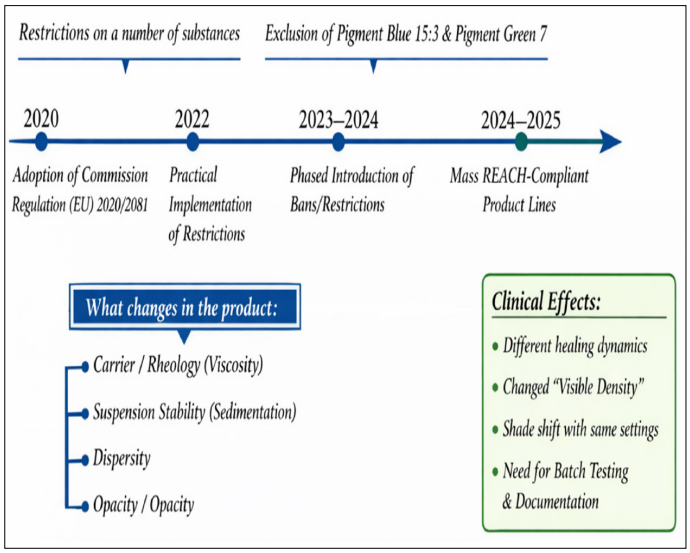

Figure 1. REACH restrictions and pigment reformulations: timeline and clinical implications (compiled by the author based on [16-20]).

The changes affected not only colorants, but also bases (carriers) and auxiliary components. Isopropyl alcohol, previously widely used as a solvent/base, at certain concentrations was restricted as an eye irritant [22]. This circumstance has practical implications: replacement of the carrier and modification of surfactant components change rheology, suspension stability, the rate of particle sedimentation, and the nature of their distribution during implantation, which can lead to differences in behavior even with a visually similar palette.

As a result, the transition to new-generation pigments that comply with REACH requirements is accompanied not only by a legal necessity, but also by a technological shift. Reformulated systems may differ in viscosity, dispersity, and colorimetric dynamics during the healing process, which increases the role of predictive assessment of the optical outcome and strict control of raw materials. The use of non-certified formulations is associated with medical and legal risks, including lack of traceability, uncertainty of the impurity profile, and невозможность of correct verification of safety [23]. At the level of clinical risk management, critical elements become batch documentation, confirmation of compliance with regulatory requirements, and standardization of protocols, allowing the result to be interpreted as a consequence of controlled variables rather than random properties of the material [23].

CHAPTER 2. AUTHORIAL MICROPIGMENTATION TECHNIQUES

Within the chapter, the practical part of the study is presented, based on experience in applying the developed protocols for work with delicate anatomical areas and scar tissue: first, data on effectiveness and satisfaction are analyzed on a sample of more than 500 procedures from 2023–2024 with assessment of operational indicators and patient-oriented metrics (VAS, BREAST-Q), including the

influence of the pendulum spraying technique and short-stroke devices on reducing intervention time and decreasing tissue load; далее in detail the аппаратная pixel method Ukladka brovei is described as a tissue-sparing alternative to microblading (needle parameters, principles of layer-by-layer gradient, adaptation of modes to skin type and scar areas, predictability of healing and colorimetric dynamics); the chapter concludes with a protocol for safe межресничное filling, where the ключевыми are anatomical zoning with preservation of the openings of the meibomian glands, depth control for prevention of pigment migration, and the choice of inert formulations aimed at minimizing ophthalmological risks and increasing the reproducibility of the aesthetic result.

Effectiveness and Satisfaction Data (Case Study)

The effectiveness of the described clinical-technical approaches is confirmed by analysis of a representative sample that included more than 500 procedures performed in 2023–2024. Operational indicators (duration of the intervention) were used as key effectiveness criteria, as well as standardized patient-oriented metrics reflecting subjective perception of the result and quality of life.

Optimization of the protocol through implementation of the pendulum spraying technique in combination with the use of powerful short-stroke devices ensured a pronounced reduction of the average procedure duration by 30%: from 2.5 hours to 1.5–1.7 hours. The clinical significance of this effect is determined by a reduction of cumulative mechanical load on tissues, which is associated with a lower probability of pronounced edema and a lower degree of traumatization, especially when working with extensive scar changes or in bilateral reconstruction of the areolar complex.

According to questionnaire data using the validated instruments VAS and BREAST-Q, 98% of patients qualified the result as excellent or good [3]. The most important predictors of satisfaction were minimal pain, visual naturalness of the achieved effect, and absence of prolonged rehabilitation, which indirectly indicates a favorable balance between the intensity of the воздействие and preservation of tissue reactivity.

Consolidated recording of operational and patient-oriented indicators makes it possible to interpret the authorial techniques as a reproducible technology rather than as a single fortunate clinical case (see table 3).

Table 3. Protocol effectiveness (case series 2023–2024, n=500+)

Indicator	Value	How to interpret in practice
Sample size	n=500+	a representative series of procedures
Mean procedure duration before	2.5 hours	baseline burden on tissues/patient
Mean procedure duration after	1.5–1.7 hours	effect of optimization of technique and equipment
Reduction in duration	~30%	less cumulative traumatization
Satisfaction excellent/good	98%	high patient-oriented outcome

From a methodological standpoint, such results require strict reproducibility of the technique: the stability of the effect is largely determined by the uniformity of pigment introduction, control of the depth of воздействия, and the predictability of particle placement within the dermal layer. Of substantial importance are asepsis standards, correct selection of consumables and device modes, as well as post-procedure management algorithms aimed at preventing inflammatory complications and minimizing heterogeneity of pigmentation, including the risks of point hyper-saturations and areas of insufficient filling.

The перспективность of the approach is reinforced by the fact that сокращение of manipulation time potentially expands the спектр of clinical situations in which gentle restoration of visual landmarks is possible without an increase in traumatization, including complex postoperative conditions and pronounced scar deformation. An additional indirect confirmation of innovativeness and professional recognition is the awarding of the Grand Prix to the author's методика at an international championship in permanent makeup, which reflects a high appraisal of both technical novelty and the quality of the aesthetic result within the professional community.

Author's Technique of Eyebrow Styling

The pixel technique under consideration is fundamentally contrasted with the widespread, but potentially more traumatic, microblading (manual hair-stroke technique). Microblading is based on performing multiple microincisions of the skin, which, under certain morphofunctional characteristics of the integumentary tissues, in particular with oily or markedly porous skin, increases the likelihood of scarring and heterogeneous repair, and also contributes to variability of the final pattern due to unpredictable healing and the phenomenon of blurring of strokes [24].

For a clear argumentation of the tissue-sparing approach, in Figure 2 an illustration will be presented with a comparison of microblading and the аппаратная pixel technique by the type of microtrauma and the nature of pigment distribution.

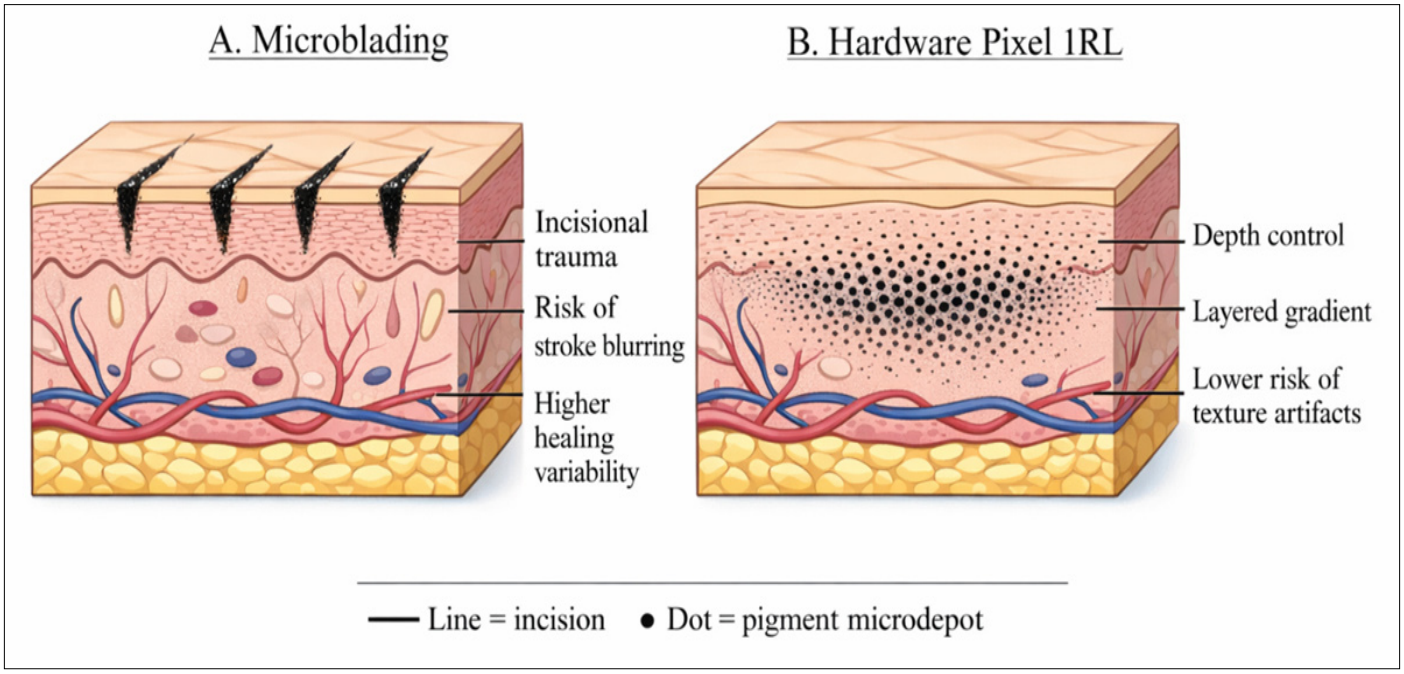

Figure 2. Microblading and pixel technique: microtrauma, pigment deposition and risk of artifacts

The key concept of the method consists in отказ from incisional воздействие and a transition to controlled pointwise introduction of pigment. A device-based technique with a 1RL needle (0.25–0.30 mm) is used, providing pixel implantation into the superficial layers of the dermis without the formation of linear incisions. Due to this, the risk of formation of грубых collagen rearrangements is reduced and the proportion of undesirable textural changes decreases, which is especially relevant in the presence of an исходной tendency to hypertrophic scarring or in heterogeneous skin architectonics.

The protocol begins with an analytical stage that includes assessment of turgor, thickness, sebum regulation, and degree of porosity, since these parameters determine the optimal device settings and movement kinematics. Selection of voltage and the tempo of needle guidance is performed taking into account tissue resistance; in the presence of scar areas, it is advisable to reduce the speed, achieving more stable penetration and uniform distribution of pigment depots without excessive mechanical load. This approach reduces the likelihood of local overloads, which otherwise may manifest as microhematomas, point hyperreactivity, and subsequent uneven фиксацией of color.

The formation of visual volume is achieved by layer-by-layer application with construction of a soft gradient from lighter to more saturated zones. Layering is performed in such a way as to imitate the natural play of light and shadow in the зоне of hair growth, creating optical density without rigid graphics. The mechanism of the aesthetic effect is based on controlled dispersion of pixel dots, which are perceived as a single powdery cloud while preserving softness of contours and absence of linear artifacts.

The final outcome is characterized by an airy, powdery result, in which subsequent lightening occurs, as a rule, more evenly, without the formation of scars and pronounced undesirable undertones provided that correct implantation modes and pigment selection are maintained [26]. An additional advantage is the predictability of healing dynamics: the absence of incisions reduces the likelihood of pronounced fibrosis, and the point архитектоника of introduction contributes to more stable distribution of color in the long-term perspective.

Safe Interlash Filling Technique

Manipulations in the periorbital region require the most delicate approach due to the anatomical and functional proximity of the meibomian glands, which ensure the formation of the lipid layer of the tear film and, consequently, the stability of its optical and protective properties. Any excessive mechanical or thermal воздействие in the projection of the excretory ducts can disrupt the microarchitectonics of glandular tissue and alter the composition of the secretion, which clinically manifests as deterioration of tear film quality and an increase in symptoms of ocular surface irritation.

The key risk is associated with performing tattooing along the wet line or with excessive depth of pigment implantation. Observational data indicate that such interventions are associated with the development of meibomian gland dysfunction (MGD), formation of dry eye syndrome, and potential loss of part of the glandular tissue [27]. Certain studies demonstrate a direct correlation between eyelid tattooing and a reduction in tear film break-up time (TBUT), which reflects a decrease in its stability and increased evaporability [28].

Since the interlash zone belongs to anatomically and functionally high-risk areas, safety measures should be formalized as a matrix risk → cause → prevention (see Table 4).

Table 4. Interlash line filling: risks and prevention in a safe protocol (compiled by the author based on [27-31]).

Risk	What triggers it	Possible consequences	Prevention (as in the text)
Transition to the wet line	proximity of the meibomian gland orifices	MGD, dry eye	work strictly within the eyelash growth zone, not on the mucosa
Excessively deep deposition	penetration into deep layers	migration blowout, shadow	depth control, avoidance of aggressive passes
Duct occlusion	trauma/chronic microinflammation	deterioration of the tear film	anatomical zoning, gentle density
Reactivity/ composition	unpredictable components	inflammation, color shift	inert highly purified pigments, traceability

The presented protocol is based on the principle of precise anatomical zoning with priority given to preservation of the meibomian gland orifices. Pigment introduction is performed strictly in the eyelash growth zone, without переход onto the mucous membrane and without involvement of the area of the glandular outlet openings. Such an approach minimizes the likelihood of duct occlusion, chronic микровоспаление of the eyelid margins, and secondary changes in the lipid component of the tear film.

The pigmentological component of the protocol предполагает the use exclusively of highly purified inorganic black pigments stated as compatible with the ophthalmic zone and characterized by a more predictable inertness profile compared with a number of organic colorants. The selection of the composition is aimed at reducing the risk of local reactivity, unpredictable color shifts, and particle migration during prolonged пребывание in tissues.

The technical part is based on superficial, gentle pigment introduction with control of depth and packing density under conditions of thin eyelid skin. The priority is minimization of traumatization and prevention of the phenomenon of migration (blowout), in which the pigment spreads into deeper layers with formation of a diffuse shadow and deterioration of aesthetic precision. Limitation of implantation depth and refusal of aggressive passes reduce the likelihood of damage to structures in close proximity and correspond to the principles of tissue preservation [15].

CHAPTER 3. PRACTICAL PART: RECONSTRUCTION AND CAMOUFLAGE PROTOCOLS

Chapter 3 systematizes a clinical algorithm for working with the most complex tasks of medical dermopigmentation: Section 3.1 presents the principles of scar camouflage as the creation of optical continuity (and not painting over) with consideration of altered vascularization and light scattering of scar tissue, criteria for candidate selection and prognosis by scar types (normotrophic/atrophic as the most predictable; hypertrophic only after stabilization and often after preliminary treatment; keloids as a contraindication), as well as the technique of multi-stage dosing, colorimetric corrections for cooling of the shade and the role of MCA/ dry needle for improving microrelief and increasing tissue receptivity. Section 3.2 describes protocols for 3D reconstruction of the nipple-areola complex, where the key elements are the construction of volume through controlled chiaroscuro, intentional heterogeneity of the areola (including imitation of textural elements) and the clinical logic of choosing 3D tattooing as a tissue-sparing final stage of reconstruction, ensuring visual completeness without additional surgical trauma.

Scar Camouflage: The Art of Invisibility

Camouflage of scar changes belongs to interventions with a pronounced range of outcomes, where the potential aesthetic gain is combined with increased requirements for candidate selection and technical precision. The ultimate objective is not mechanical overlapping of the defect, but the formation of optical continuity between scar tissue and the surrounding skin through controlled dispersion of pigment, correction of visual contrast and smoothing of perceptual boundaries. At the same time, it should be taken into account that a scar is a tissue with altered vascularization, collagen fiber density and other parameters of light scattering, therefore the same pigment concentration in a scar and in intact dermis is often perceived differently.

The most favorable prognosis is associated with normotrophic and atrophic (hypopigmented, white) scars: with sufficient maturity and stable texture they demonstrate better predictability of pigment fixation and a lower probability of a pronounced inflammatory reaction. In these cases, preference is given to pointillism or pixel spraying, allowing the creation of a granular distribution of micro-deposits with gradual build-up of density. Shade selection is performed according to the tone of healthy skin with a mandatory correction for the fact that in scar tissue the color is often visualized as cooler due to different optics and a smaller erythematous component. Of particular attention is the refusal of dense overlapping with a high content of Titanium Dioxide: with an excessive concentration of the white component, the risk of subsequent yellowing and formation of a putty effect increases, which is especially noticeable in areas with thin skin and under lateral lighting [18].

Hypertrophic scars require a fundamentally different tactic due to a tendency to prolonged inflammatory activity and remodeling. Pigmentation is permissible only after clinical stabilization: the reference point is a period of at least one year from the moment of scar formation in the absence of persistent redness, itching, soreness and progressive thickening. In most cases, preliminary treatment aimed at flattening and calming the scar is advisable (intralesional

corticosteroids, laser methods, silicone coverings and other approaches), since an attempt at camouflage against the background of active remodeling increases the risk of uneven pigment retention, усиления сосудистого компонента and ухудшения текстуры.

Keloid scars are regarded as an absolute contraindication to camouflage implantation of pigment due to the high probability of recurrence and aggressive growth of scar tissue in response to traumatization, even minimal [30]. In such situations, attempts at cosmetic correction should be limited to noninvasive visual solutions or performed within the framework of specialized treatment of scar pathology, where the primary goal is control of proliferative activity rather than masking. For applied use of the camouflage algorithm, it is advisable to fix admission criteria by scar types and conditions of process stabilization (see Table 5).

Table 5. Patient selection for scar camouflage: eligibility, conditions, and tactics (compiled by the author based on [18, 30, 31]).

Scar type	Eligibility	Conditions for eligibility	Tactics	Main risks
Normotrophic	yes	maturity, stability	pixel/pointillism, layered	cooling of tone, mottling
Atrophic / hypopigmented	yes	no active inflammation	gentle layers, blurred borders	demarcation in case of tone error
Hypertrophic	conditional	stabilization ≥ 1 year; often after therapy	fractionated sessions, minimal density	reactivation, heterogeneous retention
Keloid	no	contraindication	—	recurrence/growth after microtrauma

In high-complexity protocols, a separate place is occupied by the dry needle technique (MCA — Multitrepanic Collagen Actuation), applied before pigment introduction or as an independent procedure. Microperforation of scar tissue without pigment induces a controlled microtrauma capable of activating neocollagenesis, partially unloading fibrous bands and improving microrelief, increasing the subsequent receptivity of the area to delicate pigmentation [31]. In addition, the potential of the method in repigmentation of hypopigmented areas is described due to stimulation of melanocytes from marginal zones, although the magnitude of this effect is variable and depends on the age of the scar, the baseline density of the melanocytic pool and individual skin reactivity [32].

High predictability of the result is achieved only with strict adherence to the principles of colorimetry and dosing: scar tissue forgives density errors worse than intact dermis. Therefore, a strategy of multi-stage build-up with minimal passes, depth control and mandatory assessment of healing before the next session is preferable. Diffuse introduction of small doses reduces the risk of mottling, gray dropouts and zones of hypersaturation, which are difficult to correct due to the limited ability of the scar to retain pigment uniformly.

Safety and quality of camouflage also depend on correct pre- and post-procedural preparation aimed at reducing the inflammatory load. At the planning stage, fixation of the baseline condition of the scar is fundamentally important (photodocumentation under standard and oblique lighting, assessment of thickness, elasticity and the vascular component), because even a small shift in scar-process activity is capable of changing the visual outcome. In the recovery period, the key tasks become prevention of excessive maceration, control of irritating factors and prevention of secondary traumatization, because it is precisely the early phase of healing that determines the uniformity of pigment distribution and the stability of the optical effect in the long-term perspective.

Reconstruction of the Nipple-Areola Complex (NAC)

3D reconstruction of the nipple-areola complex (NAC) in clinical practice is regarded as the final and conceptually most significant stage of breast reconstruction, because it is precisely this that forms visual completeness and normativity of the contours of the anterior chest wall. Under conditions of absence of true projection, the key tool becomes a controlled optical model that allows transformation of a flat surface into a perceived volume without additional surgical trauma.

The coloristic architecture of 3D tattooing is based on the principles of chiaroscuro, where volume is constructed not by geometry but by gradations of brightness and saturation. In the central zone, lighter tones are used to imitate a highlight on the apex of the nipple, creating the impression of elevation. In the area of the nipple base, deeper shadows are formed, setting the effect of projection and a visual transition to the areola. The areolar part is constructed as intentionally heterogeneous: variability of halftones and microcontrasts makes it possible to reproduce natural texture, including imitation of Montgomery glands (tubercles) by means of local highlights and shadow accents, which increases naturalism and reduces the sense of a printed pattern.

Comparison with surgical nipple reconstruction emphasizes the difference in the philosophy of the methods: surgery forms physical relief, but requires additional incisions and carries a risk of complications, whereas 3D tattooing provides visual volume without incisional impact. In the absence of real projection, a higher acceptability of tattooing is often recorded, because repeated interventions are excluded and the burden of the rehabilitation period is reduced; individual studies demonstrate that satisfaction with 3D tattooing reaches 4.4/5 and exceeds the indicators of surgical nipple plasty (3.79/5), where the most frequent cause of dissatisfaction is gradual loss of projection over time [3].

CHAPTER 4. CONTEMPORARY DIRECTIONS AND DEVELOPMENT PROSPECTS

Within the chapter, two most relevant vectors for expanding the clinical capabilities of dermopigmentation are consistently considered: trichopigmentation (SMP) as a method of optical imitation of follicles to increase the visual density of hair and camouflage scars on the scalp (including post-transplantation and postoperative changes) with an emphasis on morphological assessment of the scar, controlled depth and point caliber, layer-by-layer build-up and documentation of durability in conditions with reduced retention (for example, morphea), as well as vitiligo camouflage as an intervention with increased requirements for disease stability and minimal traumatization due to the risk of the Koebner phenomenon, where the key elements become complex colorimetry on the dynamic background of the skin, dilution techniques and soft transitions, fractional sessions and integration of the procedure into the contemporary therapeutic context (including combined treatment regimens and selection of resistant zones), which together forms a practical framework for the safe implementation of these directions and prediction of the long-term aesthetic viability of the result.

Trichopigmentation (Scalp Micropigmentation - SMP)

SMP (scalp micropigmentation) is a method of optical imitation of hair follicles with formation of the shaved head effect or visual increase in density in diffuse hair thinning. On the skin of the scalp, micro-deposits of pigment create a stable pattern of follicular dots that is correctly read by the visual system as uniform stubble or as darkening of the interhair space. With regard to scar changes (after hair transplantation using FUE/FUT techniques, traumatic injuries, neurosurgical approaches), SMP occupies a special place as a camouflage tool, because it allows reduction of the contrast of the scar with surrounding tissues and restoration of visual homogeneity of the skin cover without expansion of the zone of surgical trauma.

The evidence base of 2024 indicates high clinical applicability of SMP in certain variants of scarring alopecia. In the work by Dhurat et al., the effectiveness of the method in Frontal Fibrosing Alopecia and Traction Alopecia was demonstrated, where patient satisfaction reaches 100% [34]. At the same time, a fundamental dependence of the result on the properties of scar tissue is emphasized: in scleroderma (morphea) and in pronounced dense fibrosis, pigment retention can significantly decrease (less than 50% after 6 months), which requires more frequent repeat sessions and a different strategy for building up pattern density [34].

Since SMP on scar tissue demonstrates different durability depending on nosology and fibrosis density, Table 6 will summarize clinical scenarios to expected outcomes and follow-up tactics.

Table 6. SMP in scars: scenarios, expected durability, and correction tactics (compiled by the author based on [34-38]).

Scenario	Clinical objective	Tissue features	Data from the text	Tactics
Post-FUE/FUT scars	contrast reduction	local fibrosis	dependence on morphology	layered approach, point control, photo protocol
Traumatic/ postoperative scars	visual uniformity	variable vascularization	depends on maturity	fractionated sessions, gentle depth
FFA / traction alopecia	increased density	cicatricial changes of varying degree	satisfaction 100%	conservative parameters, uniform pattern
Morphea	camouflage in sclerosis	dense sclerosis	retention <50% at 6 months	plan frequent touch-ups, moderate density

A key factor of effect reproducibility is correct morphological assessment of the intervention area: scar maturity, the level of fibrous density, the degree of vascularization, elasticity and the presence of atrophic areas determine both the implantation depth and the permissible point load per unit area. Scar tissue is characterized by an altered collagen structure and different optical conductivity, therefore pigmentation of the same intensity in intact skin and in a scar can be perceived differently; in the practical protocol this requires more cautious colorimetry, layer-by-layer build-up and mandatory control of uniformity of micro-deposit distribution.

Technologically, SMP in the scar zone is based on the principles of minimal traumatization and high repeatability of the point in shape, diameter and saturation. The point pattern must correspond to the scale of natural follicular structures, and the insertion depth must remain within limits that ensure stability without the risk of diffuse blurring and without formation of areas of hypersaturation, which look more contrastive on a scar. In dense fibrosis, more conservative parameters and fractional sessions are advisable, because aggressive saturation increases the probability of uneven fixation and accelerated mottled fading.

Particular attention should be given to management of cases with morphea and other conditions accompanied by dermal sclerosis: here reduced pigment retention is not a technical error, but a reflection of biomechanical and microcirculatory limitations of the tissue. In such clinical scenarios, a strategy of planned repeat sessions with moderate laying density is rational, as well as documentation of dynamics (photo protocol under identical lighting) for objective assessment of durability. This approach makes it possible to maintain

a balance between the aesthetic task of camouflage and the necessity to preserve the tissue-sparing nature of the procedure, especially in zones with limited regenerative capacity of the scar.

Vitiligo Camouflage

Vitiligo belongs to autoimmune dermatoses, pathogenetically associated with loss of melanocytes and, as a consequence, formation of persistent foci of depigmentation. Pigmentological correction in such cases is permissible; however, it is regarded as an intervention with increased requirements for candidate selection and for prediction of the long-term result, because the biological activity of the process and skin reactivity can substantially influence durability and aesthetic integration of color.

The key limiting condition is disease stability: performing the procedure is advisable only in the absence of progression of patches for more than one year, which reduces the probability that the formed shade will be against the background of newly expanding depigmentation. An additional risk is associated with the Koebner phenomenon, in which even dosed needle trauma can induce the appearance of new foci or enlargement of existing ones. In this regard, minimization of traumatization and strict adherence to a superficial level of insertion acquire fundamental importance, especially in anatomically vulnerable zones with thin skin and high mechanical load.

The coloristic task in vitiligo is one of the most complex in camouflage dermopigmentation. The shade of the surrounding skin is subject to seasonal fluctuations and changes depending on insolation, whereas the color of the implanted pigment remains relatively stable, which creates the risk of emphasizing the correction zone during tanning or when the skin background changes as treatment and remissions proceed. To reduce this dissonance, techniques of significant pigment dilution, layer-by-layer construction of halftones and blurring of boundaries with formation of a soft transition are used, which makes it possible to reduce contrast and make the boundary less readable [36]. Priority is given to optical integration due to low density of micro-deposits and gradual build-up, rather than an attempt to close the focus in one step with a dense layer.

Since vitiligo is characterized by variability of the skin background (insolation/seasonality), it is advisable in Figure 3 to demonstrate the problem of mismatch between the dynamics of the tone of the surrounding skin and the camouflage zone.

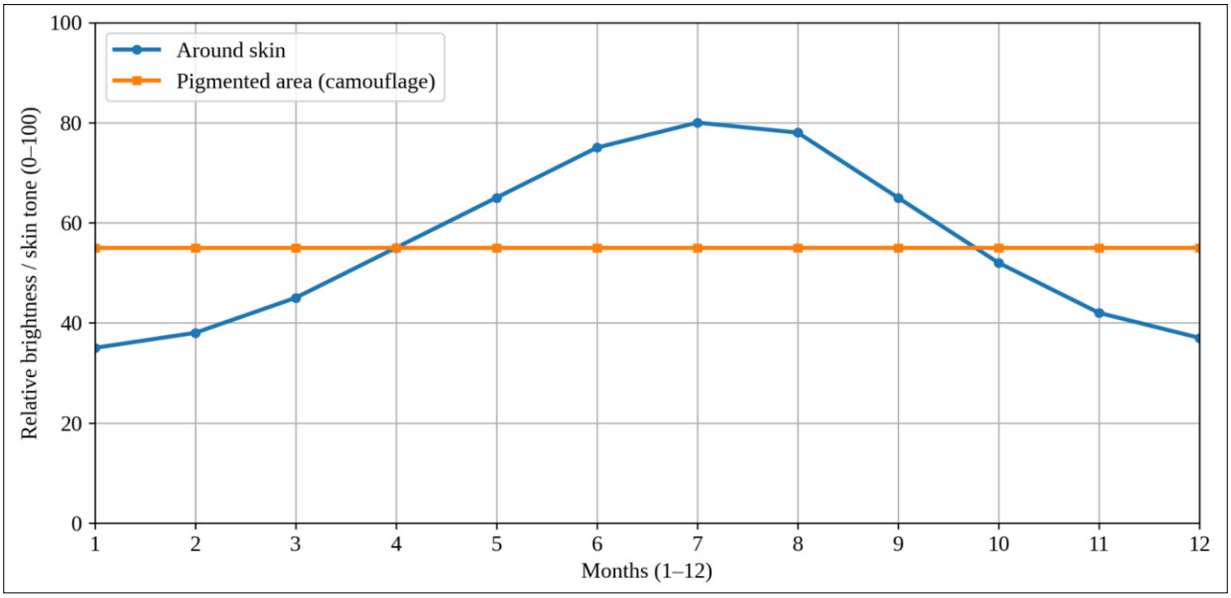

Figure 3. Vitiligo: “dynamic background” of the skin and the risk of demarcation of the camouflage zone

Particular attention is required for the clinical-therapeutic context. Contemporary data emphasize the effectiveness of combined regimens including JAK inhibitors in combination with phototherapy, which expands the possibilities of pharmacological control of the disease and increases the probability of repigmentation in a number of zones [38]. Against this background, tattooing is more often regarded as an adjunctive solution for areas resistant to therapy or traditionally difficult to treat due to features of microcirculation and functional load (hands, feet), as well as for certain anatomical regions where the rate and completeness of repigmentation are lower [38]. This position makes it possible to reduce the number of unjustified interventions and to reduce the risk of performing the procedure against the background of persisting activity of the process [39, 40].

In the practical protocol, a multilevel risk assessment is advisable: analysis of the duration and dynamics of foci, concomitant autoimmune conditions, skin reactivity and predisposition to an isomorphic reaction. To increase result predictability, sparing implantation parameters and a strategy of fractional sessions are used, allowing shade correction after assessment of healing and color behavior in a specific focus. In cases of questionable stability, a test

microzone with subsequent observation is justified, because it is precisely the individual tissue response that determines the probability of Koebner and the degree of pigment stability.

Long-term aesthetic viability of camouflage in vitiligo is largely determined not only by the accuracy of tone selection, but also by competent management of the dynamic background of the skin. Preference is given to halftone solutions and textural distribution that maintain acceptability under moderate changes in pigmentation of the surrounding skin. Excessive saturation and a rigid contour increase the risk of visual demarcation with any shift of the background (insolation, repigmentation against the background of treatment, seasonal changes), therefore optical softness and result adaptability are the dominant quality criteria in this nosology.

CONCLUSION

The obtained results make it possible to reasonably consider medical camouflage and reconstruction of the areolar complex as a significant component of contemporary rehabilitation medicine, located at the intersection of reconstructive surgery, dermatology and aesthetic correction. The evolution of the field is expressed in the transition from empirical techniques to protocols with clear biological and physical-optical argumentation. Reliance on histological features of scar tissue, immunological mechanisms of tissue response, including macrophage retention of pigment particles, as well as on the regularities of scattering and reflection of light in heterogeneous media provides a higher level of predictability, reproducibility and durability of results while reducing the frequency of undesirable effects.

The clinical viability of the author's technologies of digital eyebrow placement and sparing interlash filling is confirmed by a set of safety and satisfaction indicators, which makes it possible to qualify these methods as functionally justified within rehabilitation programs. Of fundamental importance is standardization of key parameters: implantation depth, micro-deposit density, gradient construction algorithms and patient selection criteria. Such standardization transforms dermopigmentation from a artisanal practice into a controlled medical technology, where the aesthetic effect directly correlates with the correctness of biomechanics and the precision of colorimetry.

Prospects for development of the sector are associated with further digitalization and strengthening of the regulatory and scientific base. Implementation of AI tools for shade selection and result modeling can increase the accuracy of colorimetric decisions and reduce the share of subjective errors, especially in complex clinical situations (scars, hypopigmentations, heterogeneous phototype). In parallel, improvement of the chemical composition of pigments and of standards for their safety in the regulatory field of REACH is expected, which can ensure a more transparent assessment of the toxicological profile, predictability of color behavior and reduction of risks of undesirable reactions during long-term presence of particles in tissues. An important direction remains strengthening of interdisciplinary connections between surgeons, dermatologists, oncologists, ophthalmologists and dermopigmentation specialists, because only coordinated care pathways make it possible to correctly determine intervention timing, contraindications and criteria for result quality.

From the perspective of rehabilitation, it is fundamentally important that aesthetic reconstruction in this context performs not a decorative, but a functional-psychological role: restoration of recognizable anatomical landmarks reduces the severity of bodily discomfort, increases satisfaction with the result of treatment and supports social adaptation. Thus, the final touch often acts not as a secondary addition, but as a clinically significant element of comprehensive recovery, completing the transition from the stage of treatment to the stage of stable return to everyday activity and improvement of quality of life.

REFERENCES

1. American Society of Plastic Surgeons. (2024). 2024 plastic surgery statistics report. Retrieved from: https://www.plasticsurgery.org/documents/news/statistics/2024/plastic-surgery-statistics-report-2024.pdf (date accessed: September 2, 2025).
2. Maselli, D., Torreggiani, M., Livieri, T., Farioli, G., Lucchi, S., & Guberti, M. (2024). Tattooing to reconstruct nipple-areola complex after oncological breast surgery: A scoping review. Supportive Care in Cancer, 32(3), 153. https://doi.org/10.1007/s00520-024-08351-3
3. Bellvitge Biomedical Research Institute (IDIBELL). (2024, April). Breast cancer patients highly satisfied with micropigmentation and nipple and areola reconstruction, study finds. Retrieved from: https://idibell.cat/en/2024/04/breast-cancer-patients-highly-satisfied-with-micropigmentation-and-nipple-and-areola-reconstruction-study-finds/ (date accessed: September 6, 2025).
4. Byrnes, Y. M., Lin, Y. A., Kwon, C. M., Agarwal, N., Wang, S., & Kauffman, C. A. (2025). Increasing popularity of tattoo-only nipple-areolar complex reconstruction: A 15-year retrospective study. Annals of Plastic Surgery, 94(1), 26–31.https://doi.org/10.1097/SAP.0000000000004171
5. Research and Markets. (n.d.). Scar treatment market report and forecast 2025–2034. Retrieved from: https://www.researchandmarkets.com/reports/6163361/scar-treatment-market-report-forecast (date accessed: September 10, 2025).
6. Fortune Business Insights. (n.d.). Permanent makeup market size, share | industry report [2032]. Retrieved from: https://www.fortunebusinessinsights.com/permanent-makeup-market-109710 (date accessed: September 14, 2025).

7. Kohlhauser, M., Mayrhofer, M., Kamolz, L.-P., & Smolle, C. (2024). An update on molecular mechanisms of scarring—A narrative review. International Journal of Molecular Sciences, 25(21), 11579.https://doi.org/10.3390/ijms252111579
8. Collagen morphology in human skin and scar tissue: No adaptations in response to mechanical loading at joints. (n.d.).https://doi.org/10.1016/S0305-4179(02)00267-0
9. Cell Signaling Technology. (n.d.). Mechanisms of fibrosis. Retrieved from: https://www.cellsignal.com/pathways/mechanisms-of-fibrosis-pathway (date accessed: September 18, 2025).
10. Rigau, A. R., & Dees, C. (2024). Mechanisms of fibroblast activation during fibrotic tissue remodeling. Fibrosis, 2(1), 10002.https://doi.org/10.69868/fibrosis.2024.10002
11. Ayers, F. R., Cuccia, D. J., Kelly, K. M., & Durkin, A. J. (2009). Wide-field spatial mapping of in vivo tattoo skin optical properties using modulated imaging. Lasers in Surgery and Medicine, 41(6), 442–453.https://doi.org/10.1002/lsm.20782
12. Baranska, A., Shawket, A., Jouve, M., Baratin, M., Malosse, C., Voluzan, O., et al. (2018). Unveiling skin macrophage dynamics explains both tattoo persistence and strenuous removal. Journal of Experimental Medicine, 215(4), 1115–1133.https://doi.org/10.1084/jem.20171608
13. BioCompare. (n.d.). Macrophage renewal underlies tattoo persistence. Retrieved from: https://www.biocompare.com/Life-Science-News/347741-Macrophage-Renewal-Underlies-Tattoo-Persistence/ (date accessed: September 22, 2025).
14. Death, eaters, and dark marks. (n.d.). Retrieved from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5881476/ (date accessed: September 30, 2025).
15. Halcyon Cosmetic Studio. (n.d.). Permanent eyeliner: Long-term results. Retrieved from: https://www.halcyoncosmetic.com/permanent-eyeliner-the-facts/ (date accessed: September 26, 2025).
16. European Commission. (2020). Commission Regulation (EU) 2020/2081 of 14 December 2020 amending Annex XVII to Regulation (EC) No 1907/2006 as regards substances in tattoo inks or permanent make-up. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?from=DE&uri=CELEX%3A32020R2081 (date accessed: October 1, 2025).
17. Andreou, E., Hatziantoniou, S., Rallis, E., & Kefala, V. (2021). Safety of tattoos and permanent make up (PMU) colorants. Cosmetics, 8(2), 47.https://doi.org/10.3390/cosmetics8020047
18. European Commission, Joint Research Centre. (n.d.). Safety of tattoos and permanent make-up: Final report. Retrieved from: https://publications.jrc.ec.europa.eu/repository/handle/JRC101601 (date accessed: October 5, 2025).
19. Tattoo ink products and pigments 2018–2019 upfront the new EU-REACH regulation. (n.d.). Retrieved from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12324700/ (date accessed: October 7, 2025).
20. Analysis of blue and green REACH compliant tattoo inks. (2024). Analyst.https://doi.org/10.1039/D4AN00912E
21. United States Congress. (2022). Public Law 117–328: Consolidated Appropriations Act, 2023. Retrieved from: https://www.congress.gov/117/plaws/publ328/PLAW-117publ328.pdf (date accessed: October 9, 2025).
22. Swedish Medical Products Agency. (2022, May 25). Regulations for tattoo inks. Retrieved from: https://www.lakemedelsverket.se/en/tattoo-inks/regulations-for-tattoo-inks (date accessed: October 13, 2025).
23. Heavy metal content in tattoo and permanent makeup inks and …. (n.d.). Retrieved from: https://pmc.ncbi.nlm.nih.gov/articles/PMC12656104/ (date accessed: October 15, 2025).
24. Andreou, E., Hatziantoniou, S., Rallis, E., & Kefala, V. (2024). Why permanent makeup (PMU) is not a lifetime application. Cosmetics, 11(5), 160.https://doi.org/10.3390/cosmetics11050160
25. Eyebrow microblading: Science, art, and complications. (2025). Skin Appendage Disorders.https://doi.org/10.1159/000543753
26. Timeless Skin Spa. (n.d.). The permanent makeup pixel technique. Retrieved from: https://www.timelessskinspa.com/the-permanent-makeup-pixel-technique-2/ (date accessed: October 17, 2025).
27. Effect of eyeliner and mascara use on tear film and meibomian glands. (n.d.). Retrieved from: https://pmc.ncbi.nlm.nih.gov/articles/PMC9375468/ (date accessed: December 8, 2025).
28. Eyelid tattooing induces meibomian gland loss and tear film instability. (2015). Cornea.https://doi.org/10.1097/ICO.0000000000000480
29. CTshop Cosmetic Tattoo Supplies. (n.d.). Eyeliner tattooing vs dry eye. Retrieved from: https://www.ctshop.com.au/publications/educational-articles/eyeliner-tattooing-vs-dry-eye/ (date accessed: October 21, 2025).
30. Healthline. (n.d.). Tattoo over a scar: What to know, pain level, and more. Retrieved from: https://www.healthline.com/health/body-modification/tattoo-over-scar (date accessed: October 25, 2025).
31. Accent Permanent Makeup. (n.d.). Medical tattooing.

Retrieved from: https://www.accentpmu.com/medical-tattooing/(date accessed: October 29, 2025).

32. Repigmentation of cutaneous scars depends on original wound type. (2013). Journal of Anatomy, 223(1), 74–82. https://doi.org/10.1111/joa.12052
33. Garcia, M. A. C., et al. (2025). Patient satisfaction after 3D nipple-areolar complex tattooing: A … Aesthetic Surgery Journal, 45(3), 271–278.https://doi.org/10.1093/asj/sjae235
34. Shubham, Kaur, J., Bains, P., Sharma, S., & Kapoor, P. (2025). Efficacy, safety, and patient-reported outcomes of scalp micropigmentation in scarring alopecia. Journal of Cutaneous and Aesthetic Surgery. Advance online publication.https://doi.org/10.25259/JCAS_97_2025
35. Shubham, Kaur, J., Bains, P., Sharma, S., & Kapoor, P. (2025). Efficacy, safety, and patient-reported outcomes of scalp micropigmentation in scarring alopecia. Journal of Cutaneous and Aesthetic Surgery. Advance online publication.https://doi.org/10.25259/JCAS_97_2025
36. Healio. (2024, October 18). "Just like… Monet": How paramedical tattoos can be used to treat vitiligo. Retrieved from: https://www.healio.com/news/dermatology/20241018/just-like-monet-how-paramedical-tattoos-can-be-used-to-treat-vitiligo (date accessed: November 4, 2025).
37. UMass Chan Medical School. (n.d.). Speaking of vitiligo: Should someone with vitiligo get a tattoo? Retrieved from: https://www.umassmed.edu/link/5cd81a9bc36d4be5ad782345abc3a5be/ (date accessed: November 12, 2025).
38. Mount Sinai. (2025). Mount Sinai dermatologists show promising results using combination therapy for vitiligo patients. Retrieved from: https://www.mountsinai.org/about/newsroom/2025/mount-sinai-dermatologists-show-promising-results-using-combination-therapy-for-vitiligo-patients (date accessed: November 20, 2025).
39. Becker, S. J., et al. (2021). Applications of medical tattooing: A systematic review of patient satisfaction outcomes and emerging trends. Aesthetic Surgery Journal Open Forum, 3(3), ojab015.https://doi.org/10.1093/asjof/ojab015
40. Byrdie. (2024, June 25). Eyebrow microshading vs. microblading: The real difference. Retrieved from: https://www.byrdie.com/microshading (date accessed: December 2, 2025).

APPLICATIONS

Certificates, awards, and photos of championship entries. • Tables and diagrams to facilitate understanding of the material.