Other

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ANALYSIS OF THE CAUSES OF UNWANTED COLOR CHANGES IN THE EYEBROW AREA AND DEVELOPMENT OF A PREVENTIVE ALGORITHM FOR PIGMENT SELECTION

Summary. *The article discusses the reasons why unwanted color changes may occur after the permanent eyebrow makeup procedure, and suggests measures to prevent such changes. The relevance of this topic is due to the high risk of changing the original shade of the pigment, which may negatively affect aesthetic perception and require additional procedures. The article discusses the main factors contributing to color shifts the chemical composition of the pigment, its interaction with the skin and external conditions, including ultraviolet radiation. To minimize the risks, recommendations are offered on the choice of pigment, the technique of its introduction, as well as correction and care methods that will help preserve the initial effect and prolong the beauty of your eyebrows.*

Key words: *permanent makeup, color shifts, pigments, eyebrow tattooing, chemical composition of pigments, ultraviolet radiation, and prevention.*

Relevance of the study. One of the urgent problems in the field of cosmetology and dermatology is an undesirable change in eyebrow color after a permanent makeup procedure. Despite modern technologies, the pigments and tools used for tattooing, the wrong choice of color or its interaction with the client's skin can lead to undesirable results. This can significantly reduce the

aesthetic effect of the procedure and require additional corrective measures. These changes can manifest as a darkening or lightening of the shade, as well as the appearance of unpredictable color shades such as green or blue.

Currently, a limited number of studies are being conducted aimed at in-depth study of the causes of skin discoloration and at finding effective methods to prevent them. The main factors influencing these changes include the physiological characteristics of the skin, the composition of the pigment and its chemical stability, as well as the effects of external factors such as ultraviolet radiation, age-related changes and moisture levels.

Pigment selection is the most important step to avoid unwanted changes. However, now there are no accurate and scientifically based algorithms to predict how the pigment will behave on different skin types, taking into account the individual characteristics of the client. The development of such recommendations and algorithms at the stage of pigment selection and procedure can significantly improve the quality of services, reduce the risks of undesirable consequences, and strengthen customer confidence in the permanent makeup procedure.

The purpose of the study. The purpose of this study is to analyze the causes of unwanted color changes in the eyebrow area during permanent makeup and to develop an algorithm that will help prevent them. This algorithm will take into account the physiological characteristics of the skin and the correct selection of pigment.

Materials and research methods. During the research, we used information about permanent makeup pigments (PMU) obtained from scientific publications, open sources, as well as through practical experiments and consultations with professional permanent makeup artists. The research methods included - pigment composition analysis, microstructural analysis, skin testing, assessment of the impact of external factors, coloristic analysis.

The results of the study. The pigments used in permanent eyebrow makeup (PMU) are finely dispersed coloring agents that are injected into the upper layers of the skin. This allows you to achieve a stable color effect and adjust the shape of the eyebrows. The process of permanent makeup consists in the introduction of a special pigment into the skin using a needle device under the supervision of a master. The goal is to achieve the desired aesthetic result [2].

Modern pigments for permanent eyebrow makeup (PMU) consist of two main components: a coloring agent (pigment) and a binder (carrier). The pigment is responsible for color stability, and the binder ensures a uniform distribution of particles in the solution and optimal conditions for their introduction under the skin.

By their chemical composition, pigments are divided into organic and inorganic. Organic pigments are characterized by bright and saturated shades, but require careful selection and application, as they can behave unpredictably in the thin layers of the skin. Metal oxides such as iron oxide or titanium dioxide typically represent inorganic pigments. They have a high opacity and provide a more natural color reproduction for eyebrows. Most commercial PMU pigments are hybrid, combining organic and inorganic components. This allows you to create a wide range of shades and ensure optimal color stability properties.

The composition of the pigments directly affects their behavior after injection into the skin. Microstructural analysis has shown that red and yellow PMU pigments contain mineral components such as titanium dioxide (TiO_2) and iron oxides (Fe), which determine their basic color characteristics and stability in the dermis. The presence of large agglomerates of TiO_2 particles or their accumulations can lead to unpredictable color deviations after healing, which is especially important when recording color in the eyebrow area.

The main group components of PMU pigments and their properties are presented in Table 1.

Table 1

The main group components of PMU pigments and their properties

The pigment component	Characteristic	Main application in PMU	Effect on color stability
Iron oxides (FeO, Fe_2O_3)	Mineral, dense particles	Eyebrows, natural shades	They are stable, but over time, they can acquire colder shades if mixed incorrectly.
Titanium dioxide (TiO_2)	White inorganic pigment	Lightening/mixing of shades	An undesirable cold shade may occur after healing.
Organic color dyes	Bright, saturated	A wide range of shades	They are more susceptible to changes due to exposure to ultraviolet rays and skin contact.

Source: the author's development based on the analysis of open sources on chemical components of pigments for PMU

In order to choose the right pigment for each patient, it is necessary to have a good understanding of its composition, particle size and his or her interaction with the skin. In addition, the specialist must take into account the prototype of the client, the expected depth of pigment injection, the effect of additional substances in the carrier (glycerin, water, extracts, etc.), as well as the light stability of the components. All these factors affect the final color rendering [1].

Unwanted eyebrow color changes caused by the PMU procedure may occur sometime after it is performed. They can be expressed in the "cooling" of the color, which leads to the appearance of gray, blue or green shades, or in other changes. In international practice, this process is known as "color shifting".

The main reason for these changes is the chemical composition of the pigments and their interaction with the skin. When pigment particles enter the dermis, they are affected by physiological factors such as enzymes and immune response, as well as external factors such as ultraviolet radiation. As a result, the original color may change. For example, standard warm shades may become colder over time. This is because light passes through the skin layers in different

ways and is filtered depending on the wavelength. In addition, some components of the pigment can be destroyed by ultraviolet radiation, which leads to the loss of part of the spectrum.

An equally important factor is the composition of the pigment. For example, if the pigment contains a large amount of iron oxides, this can lead to a delay in red and warm tones in the surface layers of the skin, which creates the illusion of a change in hue. At the same time, titanium dioxide and carbon black add cooler tonal elements to the pigment, which become more noticeable after healing [3].

The shift may also be related to the photodestruction of color components. Under the influence of ultraviolet radiation, the pigment structure changes, which gradually affects the perception of color. This process is similar to changing the color of paint when exposed to sunlight outside the body — the molecules lose their ability to evenly reflect the visible spectrum.

Table 2 shows the main reasons why color shifts may occur after the PMU procedure.

Table 2

The main causes of color shifts after the PMU procedure

Reason	Mechanism	The result of the shift
The composition of the pigment	Agglomeration of particles, dominance of cold components	The appearance of gray/blue shades
Interaction with tissues	Filtering light through the dermis	Loss of warm tones
Photodestruction	Exposure to UV radiation	Pallor and discoloration
Incorrect mixing of shades	Incorrect color scheme	Mismatch with the expected color

Source: author's development

The creation of an algorithm to prevent unwanted color changes during permanent eyebrow makeup should be based on reliable scientific data and professional recommendations. This algorithm takes into account the characteristics of the pigment, the condition of the client's skin and the application

technique to minimize the risk of discoloration after healing and ensure a predictable result.

The first step of the algorithm is the selection of high-quality certified pigments designed specifically for permanent makeup. According to the recommendations of experts, specialized PMU pigments differ from tattoo pigments in terms of stability, particle size, and carrier components. These differences reduce the likelihood of discoloration during the healing process and during aging of the pigment under the skin.

An important aspect of prevention is the coloristic analysis of the client's color type and skin characteristics before choosing the appropriate pigment. PMU experts confirm that incorrect shade selection, especially taking into account the skin tones (cold or warm); can lead to noticeable changes after healing. This is due to the way the skin reflects light, which affects the perception of the original shade. The algorithm uses Table 3 to visually demonstrate the relationship between the color type and the recommended shades.

Table 3

Recommendations on the shades of pigments depending on the skin color type

Skin color type	Recommended pigment shades	Note
Cold	Ashy, neutral brown	Avoid warm tones
Warm	Warm brown, caramel	Accentuate skin tones
Neutral	The balance of warm and cold tones	Universal solutions

Source: professional recommendations on the selection of pigments for PMU, confirmed by the practice of specialists

The algorithm then assumes an assessment of the properties of the selected pigment. Scientific studies show that the physico-chemical parameters of the pigment, such as lipophilicity, solubility and particle size, significantly affect the color stability and skin response to the injected dye. In particular, highly

lipophilic pigments can penetrate deeper into the skin and be excreted more slowly, which can reduce the risk of migration and unwanted color changes. The figure below clearly demonstrates the relationship between the physico-chemical properties of the pigment and its behavior in the skin.

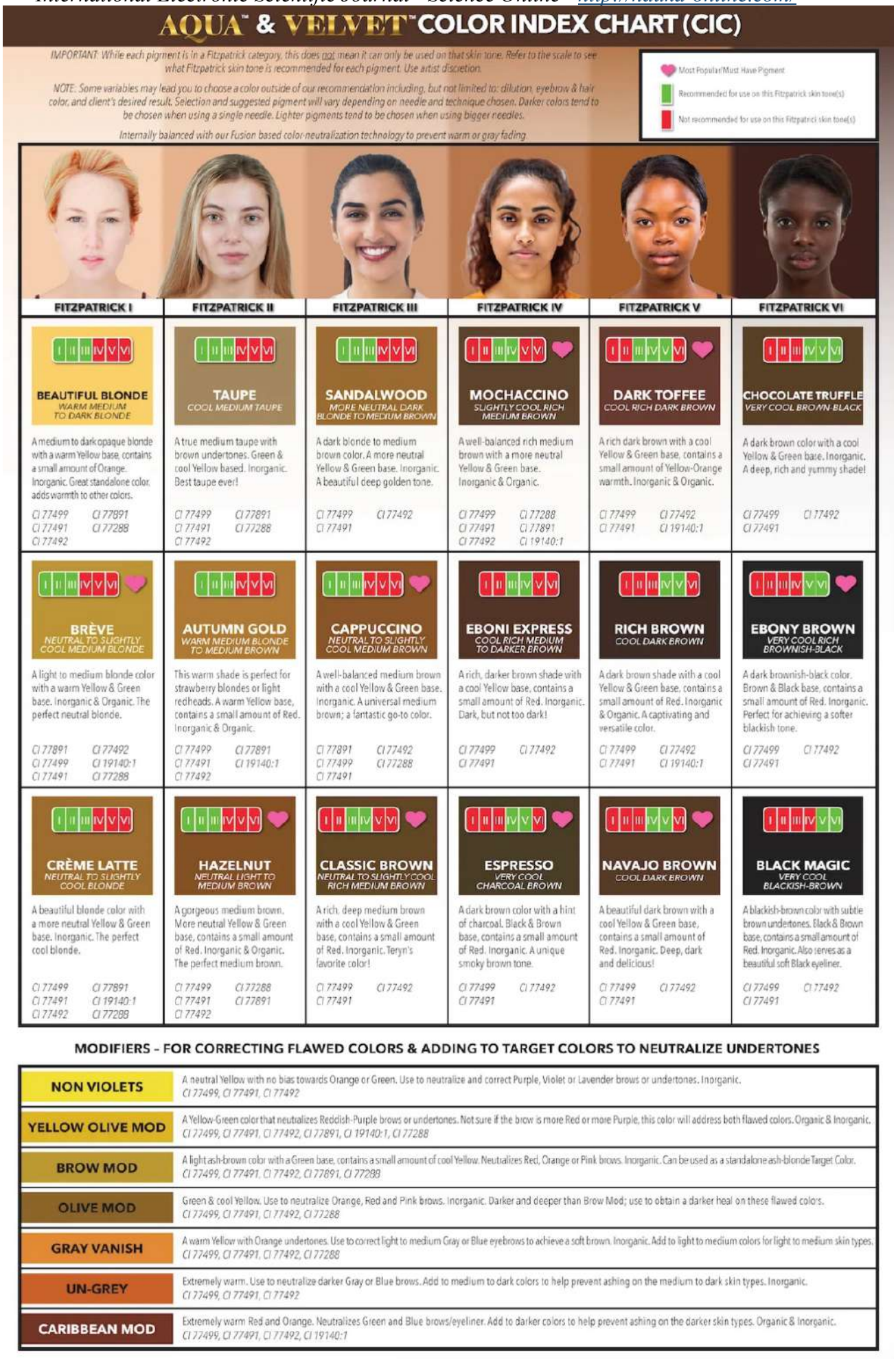

Fig. 1. Aqua & Velvet Color Pigment Index (CIC) for selecting pigment shades depending on skin type on the Fitzpatrick scale and recommendations for color correction [4]

The next stage is the assessment of the conditions for the introduction of pigment: the depth of implantation and technique. Experts emphasize that deep insertion can lead to colder shades after healing, while too superficial placement contributes to premature fading. Optimal depth and uniform distribution of pigment particles minimize the risk of discoloration.

The algorithm also includes preliminary testing of the pigment on a small area of the client's skin. For several weeks, specialists monitor the behavior of the shade, which allows them to identify a possible skin reaction to the selected pigment and adjust the strategy before the main procedure.

In addition, the procedure includes a stage of explanatory conversation with the client. During this conversation, the factors affecting the stability of the pigment after the procedure are discussed: ultraviolet radiation, skin care, age-related changes and skin phototype. Clients are advised to use products with SPF and avoid intense sunlight, which will reduce the risk of photodestruction of pigment components.

As part of the preventive approach, the condition after the procedure is monitored. During 4-6 weeks, it is necessary to monitor the healing process, evaluate changes in shade and adjust if necessary. This standard procedure complies with professional recommendations and allows you to eliminate color deviations in a timely manner with minimal risk.

To ensure high-quality eyebrow tattooing, it is necessary to adhere to the following recommendations:

- Use only high quality and certified pigments that are ideal for every skin type.
- Before the procedure, perform preliminary tests on small areas of the skin to ensure the stability of the shade.
- To train craftsmen in precise pigment application techniques, taking into account the individual characteristics of each client.

- Apply effective color correction and post-procedure care methods to minimize the risk of color changes.

The prospects for future research in the field of eyebrow tattooing and pigmentation can be distinguished in several main directions. Firstly, the properties of the pigments used in permanent makeup will continue to be studied, with special attention to their stability, resistance to external influences and safety for the skin. In particular, new pigments will be developed to minimize the risk of unwanted color changes, such as darkening or discoloration. More precisely regulating the chemical composition of pigments and improving their production technologies can achieve this.

Secondly, it is important to continue to study how individual physiological characteristics affect the perception and stability of pigment in the skin. Factors such as hormonal changes, age, skin type, moisture level, and others can significantly change the final result of the procedure. The study of these factors will allow us to create more accurate recommendations for the selection of pigments, which, in turn, will enhance the personalization of the procedure and make it more effective.

It is equally important to pay attention to how pigments behave in the environment, especially under the influence of ultraviolet radiation. As you know, UV radiation can destroy the components of pigments, changing their hue. Research aimed at identifying factors contributing to the destruction of pigments will help improve the technology of their use and reduce the number of undesirable consequences.

In addition, it is necessary to develop innovative ways to correct the pigment in case of its change after the procedure. These may be new techniques and products that will be safe for the skin and effective in the long run.

Conclusions. Thus, understanding the chemical composition of pigments, their interaction with the skin, and the effects of external factors on color stability is key to improving the quality of permanent makeup. The developed algorithm

makes it possible to reduce the risk of unwanted color changes and improve the results of procedures. In the future, it is necessary to continue research in the field of creating new pigments and correction methods. In addition, it is important to take into account the individual characteristics of each client in order to achieve the best aesthetic results.

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