INSTRUMENTAL ASSESSMENT OF THE FACE SKIN AGING IN WOMEN

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INSTRUMENTALNE METODE PROCENE STARENJA KOŽE KOD ŽENA

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ABSTRACT

The aim of this study is to conduct several non-invasive methods for assessing the level of circulatory disturbance, elasticity and aging of skin in patients of different age groups in order to expand the diagnostic capabilities and evaluate the effectiveness of current research in aesthetic medicine. Clinical and instrumental exploration of 160 women aged 17 to 75 years with varying degrees of involutional skin changes was carried out. To objectify the assessment of skin condition, in all group of patients modern instrumental methods were used, such as: elastometry, ultrasound examination of the skin, laser Doppler flowmetry, transcutaneous oxygen tension. Concurrent implementation of several non-invasive methods for assessing the level of circulatory disturbance, elasticity and aging of the skin, allowed us to find new possibilities for studying the functional state of the skin. These methods extend the possibilities of ultrasonic research methods used today in aesthetic cosmetology. The obtained comparative data of elastometry, ultrasonography, laser Doppler flowmetry and transcutaneous oximetry in patients of different age groups showed the presence of elasticity and structure defect, skin thickness and subcutaneous fat, as well as microcirculation changes since 25 years and marked changes after 40 years.

Keywords: *facial skin, instrumental diagnostics, aging, elastometry, ultrasound, laser Doppler flowmetry, oximetry.*

SAŽETAK

Cilj ove studije je da prikaz nekoliko neinvazivnih metoda za procenu nivoa poremećaja cirkulacije, elastičnosti i starenja kože kod pacijenata različite starosti sa ciljem predstavljanja drugih dijagnostickih metoda i procene efikasnosti trenutnih metoda u estetskoj medicini. Sprovedeno je kliničko istraživanje koje je obuhvatilo 160 žena starosne dobi od 17 do 75 godina sa različitim stepenom incidualnih promena kože. Da bi se objektivizovala procena stanja kože, u svim grupama pacijenata su korišćene moderne instrumentalne metode, kao što su: elastometrija, ultrazvučni pregled kože, laser i dopler metoda merenja protoka, transkutana metoda merenja zasićenošću kiseonikom. Istovremena primena nekoliko neinvazivnih metoda za procenu nivoa cirkulacijskog poremećaja, elastičnosti i starenja kože, omogućilo nam je da pronađemo nove mogućnosti za proučavanje funkcionalnog stanja kože. Ove metode proširuju mogućnosti ultrazvučnih istraživačkih metoda koje se danas koriste u estetskoj kozmetologiji. Dobijeni uporedni podaci elastometrije, ultrasonografije, laserske i dopler tehnike i transkutane oksimetrije kod pacijenata različitih starosnih grupa pokazali su prisustvo elastičnosti i defekt strukture, debljine kože i potkožne masti, kao i promene mikrocirkulacije od 25 godina i značajne promene nakon 40 godina života.

Ključne reči: *koža lica, instrumentalna dijagnostika, starenje, elastometrija, ultrazvuk, laser i Dopler metoda, oksimetrija.*

INTRODUCTION

An increase in the life expectancy of the world's population is accompanied by an elevation in the proportion of people older than 60 years (1, 2), whose number has doubled in the past half century. If in 1991 13.9% of the total population were persons over 65, in 2014 the share of pensioners reached almost 20% (3). The significant aging of the population of economically developed countries raises a legitimate interest in various aspects of gerontology. The first thing is to study the mechanisms of aging. Aging is a complex multicomponent general biological process characterized by metabolic, structural and functional changes in cells and tissues. These processes are

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formed in connection with the depletion of biological resources of the organism. Free radical processes played an important role in this process. Oxidative stress is recognized as the leading mechanism of aging, including the evolving processes of the skin (4-6). These new realities of the modern world are conditioned by new tasks of medicine. One of the tasks is to improve the quality of peoples` life of mature and advanced age, including the preservation and restoration of aesthetic health of the person, in which the condition of the skin system is considered as one of the main components.

Skin is the most largest and visible organ, which is primarily influenced not only by internal, but also by external aggressive factors. Therefore, the skin is the first visual aid of a person's age.

The availability of medicine and the priorities of a healthy lifestyle allow people to remain more active and fulfill social and physiological functions. However meeting with a mirror every year becomes more and more tragic. In this contex, the market of cosmetology services and plastic surgeries is growing exponentially in different segments every year by 2-10% (7, 8). Despite the financial recession of the last decade, the number of people using plastic facial surgery has increased. This trend can also be associated with the spread of today's most popular minimally invasive procedures (for example, injections of botox, collagen, etc.) (9). So, only in the USA in 2016 more than 16 million cosmetic procedures were performed, including minimally invasive procedures, the cost of which exceeded $ 13 billion (10, 11).

The growth of the aesthetic services market is accompanied by a simultaneous increase in equipment for carrying out cosmetic or surgical procedures. However, there are no large studies that allow you to objectively choose methods of treatment are based on the state of the skin system according to diagnostic hardware systems (11-15). Perhaps this is due to the lack of objective criteria for assessing the state of the skin system.

In this regard, the interest of physicians to new modern functional methods of treatment and research is increasing, allowing timely and reliable assessment of the skin condition, as well as the effectiveness of the therapy used. The authors made an attempt to apply diagnostic systems known in general clinical practice to assess the age-related changes in the skin system.

The purpose of the study is to assess by non-invasive methods the degree of skin aging on the parameters of blood flow and skin elasticity in patients of different age groups.

MATERIAL AND METHODS

Study population

Clinical and instrumental examination of 160 women aged 17 to 75 years, divided into 4 age groups of 40 people each (1st group - up to 25 years inclusive, 2 group - 26-35 years, 3rd group - 36-50 years, the 4th group is over 50 years old).

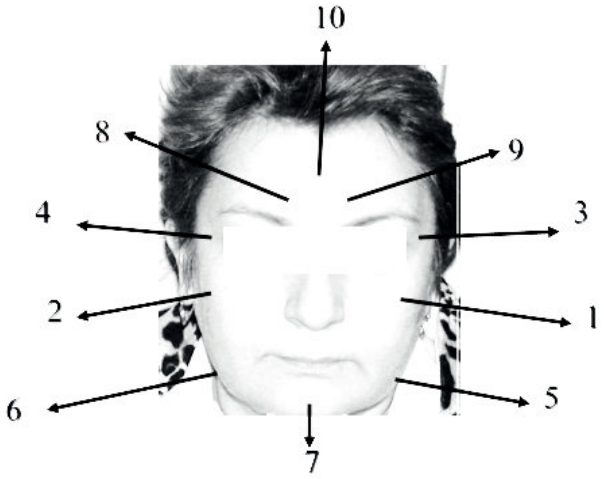

Figure 1. Points on the face for instrumental evaluation of the skin

Methods

To assess the skin condition of all the patients objectively, modern instrumental methods of investigation were used, such as: elastometry, ultrasound examination of the skin of the face, laser doppler flowmetry, transcutaneous oxygen tension.

Measurement of skin elasticity

Measurement of skin elasticity (elasticity) was carried out using the ElastometrR EM 25 device from Courage + Khazaka electronic GmbH (Germany). The degree of elasticity of the skin is determined optically during its suction and is displayed in percentages on the instrument screen and a diode indicator. This measurement was performed around the face at 10 points: cubic (1, 2), orbital (3, 4), mandibular (5, 6), chin (7), and frontal (8-10), as shown in Fig. 1.

To study the structural features of involutional skin changes, ultrasound investigation of the dermis and epidermis was carried out by the method of two-dimensional ultrasound scanning of the skin. Ultrasound investigation (ultrasonography) was performed in 10 standard points of the patient`s face using the LOGIC 1200 apparatus in the "small pats" mode, which allows to reliably estimate the skin type of the patient and identify the most problem areas for more intensive medication.

Measurements of skin microcirculation

Measurements of skin microcirculation by laser doppler flowmetry was performed with using a single-channel BLF-21 laser Doppler flowmeter from Transonic System Inc. (USA) with a surface sensor type "R". Laser doppler flowmetry is based on laser tissue sounding and subsequent recording of radiation reflected from mobile and immobile tissue components. The signal registered with LDF characterizes the blood flow in microvessels in a volume of 1-1.5 cm^3 tissue. The studies were carried out for 15-30 seconds at each of 10 points, after stabilization of the perfusion blood flow parameters. During the study, perfusion

indices of the skin (PS, in conditional perfusion units) and the mean square deviation of the amplitude of the blood flow fluctuations from the arithmetic mean value were calculated.

To directly assess the state of skin metabolic processes, the examination of the state of the tissue (intracutaneous) oxygen tension was made. It was studied by a non-invasive method of transcutaneous oximetry (TO_2) based on the principle of polarographic detection of oxygen in biological objects using the TCM 400 Radiometer device (Denmark).

Statistical analyses

All data are presented by descriptive statistic methods, as mean, median, standard deviations, quartiles, minimum and maximum, as well as frequency of variable in percent (%).

RESULTS

According to the data of elastometry, the heterogeneity of tissues in various areas of the face was revealed. Comparative analysis of elderly patients` skin elasticity in 6 points (3, 4, 7, 8, 9, 10) showed a significant decrease in elasticity indices by 15-25% ($p < 0,05$) (Tab.1).

The best indices of elasticity were registered in group 1 (young patients), especially in the paraorbital region (points 3-4) and in the chin area (point 8). In the second group (26-35 years), the indices decreased reliably: by 13% in the paraorbital region (points 3, 4) and by 10% in the forehead area (points 8, 9, 10). This suggests that these areas are the first problem areas for the wrinkles appearance and need careful attention and care since 25 years. After 35 years (groups 3 and 4), a significant decrease in elasticity was observed at all points. Particularly at this age a deformation type of age-related changes begins to appear. It is ptosis of soft tissues, whose marker is the decrease in elasticity at points 5, 6, in the face oval area. The maximum degree of decrease in elasticity, diagnosed at almost all points, was found in patients over the age of 50 years. By this period, the majority of patients had already formed a deformational type of involutional changes in the skin of the face of the second degree, and in some cases also of the third degree. The results obtained reflect the redistribution of mechanical stress in the examined areas of the facial skin surface.

Consequently, measuring the elasticity of the skin can serve as an objective criterion in the exteriorization of the degree and nature of involuntary changes in the facial skin. In addition, carrying out these survey methods can help in choosing the method of surgical correction in older patients. That is because atrophic skin processes leading to a marked decrease in its elasticity can affect the results of surgical correction, making them less stable in the duration of the effect than in patients of younger age groups.

Analysis of involutional changes in the state of the skin system according to ultrasound parameters revealed that the thickness of the skin and subcutaneous fat depends on the type of skin and body mass index of the patient, directly correlating with the latter. The smallest thickness of the skin, from 0.06 to 0.07 mm, is noted in the paraorbital region, and the largest - in the forehead region, where it is from 0.08 to 0.1 mm.

Table 1. Elasticity of patients` skin in different age groups.

Measurement points	Group 1 (≤25 years)	Group 2 (26-35 years)	Group 3 (36-50 years)	Group 4 (>50 years)
1	34 29 / 39	42 35 / 58	64 55 / 69	68 63 / 78
2	34 28 / 40	38 34 / 50	66 56 / 73	72 62 / 79
3	39 31 / 45	43 35 / 49	66 58 / 70	79 70 / 87
4	38 30/43	39 32 / 46	65 56 / 70	78 71 / 85
5	33 29 / 39	34 30 / 41	67 60 / 75	74 68 / 79
6	34 30 / 40	35 31 / 43	70 62 / 79	73 65 / 81
7	44 34 / 50	48 43 / 57	78 64 / 85	82 78 / 89
8	42 33 / 48	42 37 / 50	68 62 / 77	76 70 / 82
9	42 34 / 45	44 39 / 50	68 60 / 76	74 66 / 79
10	43 35 / 46	46 38 / 53	65 58 / 70	75 68 / 80
The results are presented as Medians (first line) and lower 25% / top 75% quartiles (second line)				

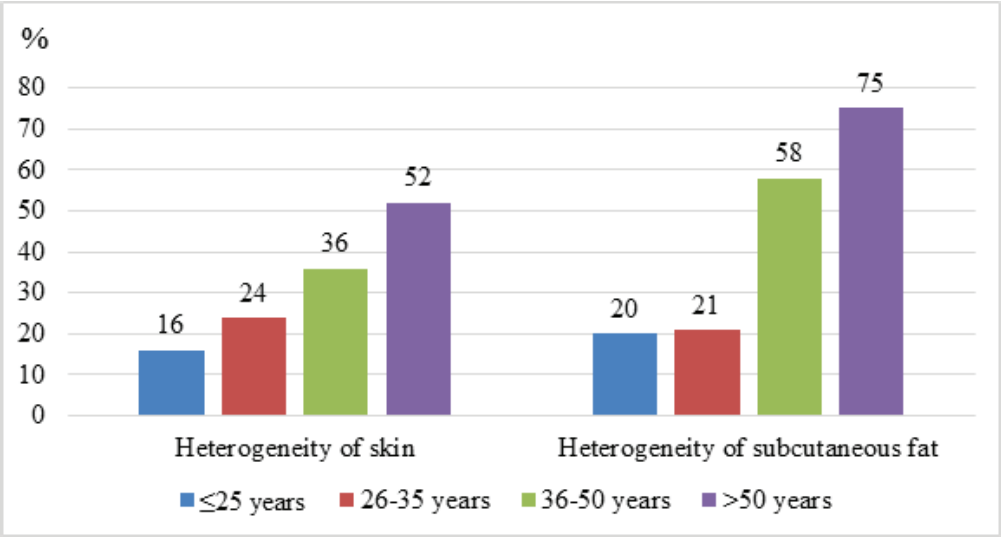

Figure 2. Indicators of the structural organization of the skin (% homogeneity and echogenicity (heterogeneity) of subcutaneous fat in patients of different age (p<0,05).

In the course of the study, a significant decrease in skin thickness was recorded, It had a reverse correlation with age in patients in groups 3 and 4, whose thickness of skin and subcutaneous fat was on average 0.01-0.02 mm less than in more young patients, respectively, the 2nd and 1st group ($p < 0.05$). In addition, there was a progressive thinning of the skin with age and a significant increase in the heterogeneity of the structure of the skin and subcutaneous fat, especially noted in patients after 50 years (Fig. 2).

The significant growth of structural heterogeneity occurring simultaneously with atrophy is caused by different degrees of tissue dismetabolism in different areas of the facial skin. These processes are secondary to different anatomical structures, and thus having different degrees of microcirculatory disorders and different levels of functioning of fibroblasts producing collagen.

According to laser Doppler flowmetry (LDF), it was established that the parameters of skin microcirculation changed significantly with age. However, while comparing border groups, this reliability was not obtained, which later served as the reason for refusing to adopt a generally accepted division into narrow age groups. Thus, the average total LDF (including the total quantitative representation of blood flow in all measured points of the face) in patients under the age of 25 years was 8.0 ± 1.63 ml/min, while in women older than 50 years the value of LDF was 6.5 ± 1.4 ml/min ($p < 0.05$). It was established that the LDF indicators varied in different areas of the face. The highest values of indices of blood supply were noted in the frontal and mandibular regions (points 5, 6, 8-10). This confirms the direct correlation between age and levels of tissue (intradermal) microcirculation.

Quantitative LDF results, which characterize the decrease of microcirculation parameters with aging, correlated with the results of the study of microcirculation parameters for transcutaneous TO_2 oximetry, characterizing the age-induced involution of tissue oxygenation (Tab. 2).

The obtained data confirm the hypothesis about the predominant influence of the microvasculature (blood flow level and oxygen level) on the metabolic processes in the skin. Therefore, the improvement of metabolic processes in cells should be an integral component in the pathophysiologically directed treatment of involutional changes in the skin system. That is because, any tissue ischemia and hypoxemia, including in involutional changes in the skin system, revealed in our studies, lead to the actual mechanisms of skin aging.

DISCUSSION

The purpose of the study is to assess by non-invasive methods the degree of skin aging on the parameters of blood flow and skin elasticity in patients of different age groups. Skin is a multifunctional organ but, alongside every other organ system, is subject to both intrinsic (chronological) and extrinsic (environmental) aging, resulting in a loss of functional capacity. Cutaneous aging manifests as an observable change in the external appearance of the skin, the major accelerator of the aging process being our interactions with our environment, such as chronic exposure to solar irradiation (UV, IR or visible wavelengths of light) (11-14).

Groups	LDF ml / min	TO2 (mm Hg)
I, 18-25 age	8.0 ± 1.63	54 ± 6.5
II-III, 26-50 age	7.4 ± 2.0	45 ± 3.6
IV, over 50 age	6.5± 1.4	37 ± 4.7

Table 2. Indices of tissue oximetry and microcirculation of the facial skin in patients of different age. Results are presented as mean ±standard deviations

Topics of involutional changes in the skin system are basic for cosmetologists and, to a large extent, plastic surgeons. Specialists in these areas, using the concept of age-related skin changes, use mainly subjective scales for assessing skin types and aging. A large number of these scales, actively applied in practice, once again prove the dissatisfaction of specialists with these scales and their subjective assessment. All this does not allow to realize a fully personalized approach while choosing conservative or surgical treatment, and also to objectify the effectiveness of the treatment.

The development of medical technology makes it possible, on the basis of data from instrumental survey methods, to obtain digital indicators for many characteristics of the skin system. The most important of these are the elasticity and density of the skin, as well as its blood supply. In the last few years, there has been increasing demand for aesthetic procedures to improve the effects of skin aging. Previous authors evaluated the anti-aging efficacy, tolerability and skin changes induced by the topical products containing hyaluronic acid, N-acetyl glucosamine and gamma-amino butyric acid through instrumental techniques, clinical and subjective evaluation (12). A clinical assessment of smoothness, expression wrinkles, fine wrinkles and measurements of the parameters using Reveal Imager, X-Rite, Corneometer, Dermalab, Moisture Meter EpiD were taken at day 0, 15, 30 and 60 of study period. A final assessment questionnaire was submitted, and they conclude that the efficacy of the topical products is confirmed by subjective, clinical and instrumental assessment which should be a routine approach in dermatologic practice (12).

The parallel study of several non-invasive methods for assessing the degree of disturbance of blood flow, elasticity and aging of the skin allowed us to find new possibilities for an objective evaluation of the functional state of the skin. The obtained comparative data of elastometry, ultrasound, laser Doppler flowmetry and transcutaneous oximetry in patients of different age groups show age-related disorders of elasticity, structure, and thickness of the skin (7, 8). Iyengar and coauthors investigated the ultrasound as an investigating method, which is relatively deeply penetrating and can be used to evaluate deep dermal and subcutaneous structures (13). They concluded that ultrasound is an inexpensive, noninvasive, and convenient means to monitor dermatologic conditions and guide their treatment (13).

On the other hand, with age, there is a decrease in elasticity, the heterogeneity of the skin and subcutaneous fat is progressing, by means of reducing the collagen content in it, and also reducing the blood supply to the skin system. The first involutional changes are recorded in the areas of the thinnest skin (paraorbital regions). On such areas it is already necessary to pay attention from the age of 25 with the conduct of adequate cosmetic procedures.

After 40-50 years, especially in the menopausal and postmenopausal period of women, changes in skin indices begin to be expressed, a deformational type of involutional changes is formed, ptosis, the oval of the face is deformed. Kimball and colleagues demonstrates a wide range of molecular processes in skin affected by aging, providing relevant targets for improving the condition of aging skin at different life stages and defining a molecular pattern of epidermal gene expression in women who appear younger than their chronologic age (18). On the other hand, men are a growing patient population in aesthetic medicine and are increasingly seeking minimally invasive cosmetic procedures. Findings from study Rossi and coauthors conducted in a globally diverse sample may guide clinical discussions with men about the prevention and treatment of signs of facial aging, to help men of all races/ethnicities achieve their desired aesthetic outcomes (19).

Therefore, in order to preserve aesthetic youth, patients of older age groups should be under the constant supervision of specialists, including a plastic surgeon. Newton and coauthors described that cutaneous aging manifests as an observable change in the external appearance of the skin, the major accelerator of the aging process being our interactions with our environment, such as chronic exposure to solar irradiation (UV, IR or visible wavelengths of light) (15). Longo and coworkers suggested that a precise and noninvasive quantification of aging is of outmost importance for *in vivo* assessment of the skin aging "stage", and thus acts to minimize it. Several bioengineering methods have been proposed to objectively, precisely, and non-invasively measure skin aging, and to detect early skin damage, that is sub-clinically observable (16). Other authors, but suggested different methods for diagnosis skin aging (17). The Skin Ageing Index was defined as the normalized projection of the clinical grading values on the first Principal Component Analysis (PCA) axis. Several Skin Indexes were built by grouping specific parameters related to a skin condition such as overall ageing, wrinkles and sagging. All indexes were highly correlated with the real and the perceived age ($0.57 \leq$ Pearson $R \leq 0.92$, P-value ≤ 0.05) (17).

First Consensus on Primary Prevention and Early Intervention in Aesthetic Medicine published guidelines regarding to facial aging as an complex interplay of extrinsic and intrinsic factors leading to progressive changes in the skin, subcutaneous tissue, and bone. Clinical experience suggests that early aesthetic intervention may slow the signs of aging, but treatment in the absence of symptoms or with minimal signs of aging has not yet been properly addressed (20, 21). Preventive measures and early therapeutic interventions that may alter the course of facial aging were defined. Further studies are needed to support these recommendations with the best possible evidence.

CONCLUSION

The work carried out by us demonstrates the possibilities of non-invasive instrumental diagnostic methods used in modern aesthetic cosmetology and plastic surgery. These methods should be used not only at the stages of ascertaining the condition of the skin system, but also for choosing a method of treatment and monitoring the effectiveness of conservative and surgical methods of correcting age-related changes.

It is important to note that even with the best modern plastic methods of treatment, the blood supply function is paramount, ensuring an adequate recovery of the dermal cell pool and eliminating the mechanisms of apoptosis. In this connection, physiotherapeutic and pharmacological methods, which contribute to the expansion of the microcirculatory channel on the face, can be useful. Such complex therapy will help to achieve the best result of treatment of involutional skin changes.

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