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FEATURES OF ULTRASOUND DIAGNOSTICS OF POSTOPERATIVE HYPERTROPHIC AND KELOID SCARS

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ABSTRACT

The problem of pathological skin scar as the final stage of wound healing is currently a topical issue. We have studied the possibility of differential diagnosis of head and neck hypertrophic and keloid scars, by establishing its echogenic differences using ultrasound. We observed 50 patients aged from 15 to 30 with hypertrophic and keloid scars on the head and neck. We have selected patients with optically visualized hypertrophic painless scars which were formed within several weeks. There were enriched blood vessels inside the wound. The intact skin obtained from 50 healthy people was used for comparison. While speaking about a group of patients with keloid scars, it should be noted that formation of this type of scarred tissue lasts for several months, occurs in the age of 25 to 40, is painless but with itching, extending beyond the wound. Ultrasound differentiation of postoperative hypertrophic and keloid scars of layered structure was applied, taking into account the fact that the echolocation wave (21-25 Kts frequency) may change the penetration rate depending on the density and elastic qualities of dermis and subcutaneous fatty epidermis tissues.

In this research, ultrasound revealed that the hypertrophic scar tissue was visualized with clear contours, its thickness decreases along the periphery of the scar and reaches its maximum values in its center. In 97% of cases it was characterized by a hypoechogenic sign that, in our opinion, is an important ultrasound characteristic. The study marked a decrease in the thickness of keloid scars when compared to hypertrophic scars by 18-26% on the average. With regard to the echogenicity of this type, its unevenness in all areas should be noted. Gipoehogennye areas of irregular polygonal form were recorded in 62% of cases. Ultrasound of scars is a non-invasive method of examination, through which it is possible to evaluate numerous anatomical structures objectively, informatively and safely as well as to determine the type and depth of scar formation. This method allows to establish echogenic differences of postoperative hypertrophic skin scars in comparison with the intact skin by mean of ultrasonic waves.

KEYWORDS: *hypertrophic scar, keloid scar, ultrasound examination, echogenicity.*

INTRODUCTION

Despite the possibilities of modern surgery and dermatology, the problem of prophylaxis and treatment of patients with hypertrophic types of scar tissue is still relevant. Currently, scientific interest in the life-time study of anatomical structures with the help of non-invasive methods, one of which is an ultrasound investigation is growing [*Karasiunok A, Smahliuk L, 2015*]. This method allows informative and safe assessment of various tissues, including the skin. There are data on positive results of using ultrasound to study skin changes in cases of psoriasis, dermatitis, vitiligo, tumors [*Kuroedova V et al., 2017; Lebo P et al., 2017*].

Ultrasonic scanners with 50 *mHz* and 20 *mHz* frequency are usually used for skin examination. A device with 50 *MHz* frequency does not practically penetrate the skin and is used only to assess the epidermis. The depth of the echo signal at an ultrasonic wave of 20 *mHz* frequency is 1-1.5 *cm*, which allows to use such scanners to examine epidermis, dermis and subcutaneous fat. Diagnostic devices using lower frequencies which are needed during the skin examination are almost not used due to

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insufficient information. Taking into consideration the importance and variety of facial functions, many of which are involved in the implementation of communicative human needs, rather low effectiveness of eliminating pathological scars of maxillofacial area should be of a particular attention. In our opinion, the examination as well as best method choice for further operative and conservative treatment for this category of problem should be developed [*Lakin G, 2015*].

The formation of pathological scars in maxillofacial area is constant problem of plastic and reconstructive surgery. The issue of formation prognosis of certain scar type remains unresolved until today [*Loza X et al., 2016*]. Over the past decades, there has been increased interest in the problem of scarred and altered tissues in the maxillofacial area, due to increasing prevalence of this condition among the population [*Neligan P, 2013*]. According to some authors, postoperative abnormal scars can be caused by a violation of face chewing muscle biomechanics, which can lead to stomach muscles diseases and to dentition deformation in young people, which further requires a multidisciplinary treatment approach with orthodontist participation. The recent volume of information about causes and mechanism of pathological scar in skin has significantly increased, but most of hypotheses have not been tested in the human body. In plastic surgery, awareness of preventive methods, diagnosis and adequate treatment of hypertrophic scar is of particular importance, since pathological scars often have an uncontrolled course, are difficult to treat and are prone to relapse [*Osinsky V, 2007*].

As clinical practice shows, the fact and the value of a functional and aesthetic defect in scar skin changes as well as the degree of their negative influence on the process of physical, psychological and social adaptation of the patient are of the fundamental importance, which makes this problem both medical and social. Reliable pathogistological differences of the scar tissues of different etiology are established at present. Many authors believe that in most cases the cause of unsuccessful treatment of pathological scar is due to imperfect, less informative methods of differential diagnosis. A significant number of works are devoted to the study of diagnostic methods of pathological scar on the head and neck , but they are not systematized, having their disadvantages [*Skrypnyk V et al., 2012; Smaglyuk L et al., 2018*].

It becomes clear that the issue of examination and treatment of patients with pathological scar of head and neck remains open till today. Therefore, in our opinion, the development of optimal correction ways of scar tissue should be based on clear definition of scar various types as differential diagnosis criteria. The urgency in development and improvement of the diagnosis and treatment quality of the patients with facial scars, which are formed due to both planned and urgent surgical interventions, burns and mechanical injuries is beyond doubt [*Kuong V et al., 2014; Voronkova H, Smahliuk L, 2018*].

That is why, effective treatment of patients with head and neck hypertrophic and keloid scars is possible only with optimization of differential diagnosis of various types of scar tissue.

Material and methods

Ultrasound examination was performed in 50 patients with head and neck hypertrophic and keloid scars. These scar tissue types have been confirmed after examining the patients as well as using morphological examination methods.

Ultrasound differentiation of postoperative hypertrophic and keloid scars of layered structure was applied, taking into account the fact that the echolocation wave (21-25 *Kts* frequency) may change the penetration rate depending on the density and elastic qualities of dermis and subcutaneous fatty epidermis tissues.

The change in frequencies of ultrasonic waves allowed to determine the rate of their spread, both in the intact skin and in hypertrophic and keloid scar tissue. The difference in the ultrasound frequency, called the acoustic impedance, which was calculated in different layers of skin and pathological scar tissue is established.

In the research we used the ultrasonic wave reference pulse mode and established the difference between wave permeability indices, some of which passed through all the layers of dermis and partially reflected from each of its layers. Calculating the time between the beginning of pulse formation and its reflection from certain layers of skin, the depth of hypertrophic and keloid scars occurrence was determined. For the purpose of mathematical

substantiation and establishment of quantitative indicators of echogenicity among zones of US – grams degree we selected the following points:

T1 – area of the intact skin around the scar;
T2 – a part of a medial edge of the rumen;
T3 – the area of the scar lateral edge;
T4 – the middle area of the rumen;
L1 – the boundary between the epidermis and the scar tissue;
L2 – the border between the scar tissue and the hypodermis;
L3 – the boundary between the medial edge of the scar and intact derma;
L4 – the border between the lateral edge of the scar and the intact derma.

To objectivize the data we have introduced 2 coefficients:

L1/2 – the index which shows the nature of change in the echogenicity indices in the central and peripheral tissues of the scar in its middle zone;
L3/4 – the index which shows the nature of the change in echogenicity in medial and distal edges of the scar.

Results

It has been established that the average echogenicity index of the intact skin is 72.8, whereas in women this figure was slightly higher (78.4) than in men (66.2).

When using ultrasound to study postoperative hypertrophic scars we found the following differences. The epidermal scar tissue reduced echogenic structure and was homogeneous, close to the intact skin, but in 100% of cases it had a deep occurrence of the average of 0.22 to 0.58 *mm*, which is 26-41%. It is noteworthy that the occurrence of hypertrophic scar was observed at a considerable depth and reached variable values from 1.6 to 4.3 *mm*. This fact, in our opinion, should be used in the primary diagnosis of this type of scar.

In 97% of cases, the structure of the scar itself was hypoechoic and a decrease of 8-14% was marked. In 92% of scar tissue ultrasound tests, the tissue was visualized with clear, limited contours whose thickness decreases along the periphery of the scar and reaches the maximum values in its center, which in our opinion is an important ultrasound characteristic of hypertrophic scar.

It should be noted that the depth of hypertrophic scar occurrence varied from 1.6 to 4.3 *mm*, which is an important feature in primary diagnosis of this type of scar.

Noteworthy is the fact that the scar has a clear border with the intact skin and subordinate tissues. In 13% of cases, the zone was instantly visualized in scars of the diseased tissues, echogenicity reduced and increased simultaneously, whereby hyperechoic areas were often observed in peripheral areas of the scar, and a hypoechoic center, resembling an elongated circle or ellipse.

Analyzing the data for numerical differences in terms of echogenicity of hypertrophic scars, it should be noted, that the value of the intact skin parameters was not significantly different from that in the previous study groups and averaged 86.1 (88.9 in women and 83.2 in men). Noteworthy is the fact that the difference in echogenicity changes in the value of indicators in the area of medial and lateral edges of the scar had big differences, making up to T2 – 76.4 (78.7 and 73.6, in women and men respectively) and at the T3 point – 76.5 with similar sexual characteristics in discrepancies between these groups.

It was shown that echogenicity index in the middle scar region was significantly reduced compared to the intact skin and averaged 59.8 (61.4 and 57.6, in women and men respectively) (Table 1).

We obtained data on the true differences between values of echogenicity at the border of the scarred hemmed tissues with epidermis and hypoderma, which were 62.1 (66.8 in women, 58.2 in men) and 93.1 (96.4 in women, 87.2 in men). Obviously, this indicates the uneven density of hypertrophic scar tissue in its surface and deep layers, which, in our opinion, is a significant addition to the scar differential diagnosis. Analyzing the indices in the areas between the medial and lateral edges of the scar and dermis, a significant reduction of these indices was determined in 66.1 cases (69.3 in women, 63.8 in men) and 63.1 (in women – 66.9 , 59.2 in men) which in our opinion may indicate a heterogeneous density of connective tissue elements in different edges of hypertrophic scar. Indicator L1/2 according to received data had the smallest values in comparison with the intact skin. That indicates a greater density and chaos of connective tissue fibers direction along the periph-

Table 1

Distribution of hypertrophic scar echogenicity indices in ultrasound examination

Observation	T1	T2	T3	T4	L1	L2	L3	L4	L1/2	L3/4
1	86	77	78	61	57	98	63	60	0.60	1.05
2	90	82	79	62	56	95	60	55	0.60	1.09
3	82	71	73	61	72	102	75	74	0.70	1.01
4	88	79	81	60	51	85	51	50	0.60	1.02
5	89	80	83	61	69	94	72	75	0.73	0.96
6	85	76	77	62	62	90	61	62	0.70	0.98
7	84	74	74	61	53	88	59	59	0.60	1.00
8	92	81	80	67	71	102	74	79	0.70	0.94
9	80	71	72	54	73	102	80	81	0.71	0.99
10	79	72	68	51	61	90	65	66	0.67	0.98
11	83	74	73	57	54	87	66	62	0.62	1.06
12	92	81	79	62	72	90	72	74	0.80	0.97
13	89	78	81	58	50	82	52	55	0.60	0.95
14	78	68	66	56	52	85	60	61	0.61	0.98
15	94	82	84	64	77	107	81	84	0.71	0.96
Medium Value	86.1	76.4	76.5	59.8	62.1	93.1	66.1	63.1	0.66	0.99

ery of hypertrophic scars. This feature should be taken into account at the stage of primary diagnosis. At the next stage of the study, we attempted to create a standardization table for echogenicity distribution of different types of scar tissue in different zones of ultrasound. In our opinion, the digital characteristic of variational series of echogenicity indicators obtained at certain points may indicate a correlation between the scar density in different zones, the degree of its echogenicity at these points and its affiliation to a certain type.

In ultrasound visualization the colloidal scars are marked by a decrease in their thickness, when compared to hypertrophic scars on average by 18-26%. In our opinion, this occurs due to the reduction of the granular layer with hypoplasia of keratinocytes in the studded layer. In 72% of studied keloid scars, it was possible to visualize the subepidermal region due to mucoid swelling of collagen fibers and smoothing of dermal papillae. The most significant changes were recorded in ultrasound examination of intact derma and scar tissue. The depth of occurrence was quite variable and reached the highest values, even in comparison with the hypertrophic scars studied - from 4.8 to 13.1 *mm*. Regarding the echogenicity of this zone, it should be noted that it is uneven in all areas in 62% of cases, echogenic areas of irregular polygonal form were recorded, which in our opinion coincides with the zones of keloid growth and morphologically corresponds to the areas with high content of giant fibroblasts.

It is worth noting that along the whole lenghth of scar tissue, the boundary between it, the intact skin and subordinate tissues is not observed, which is a distinct differential sign of keloid scar.

Only in 7% of cases we visualized the border with hypodermis in the peripheral edges of rumen, which indicates the infiltration character of the keloid growth and proves once again its similarity to tumor.

Analyzing the digital data table, it should be noted that the most differences in values were observed precisely among the indicators of echogenicity of this scar group, indicating the diversity of their clinical manifestations.

The fact that draws attention is that the average value of echogenicity index of the intact skin around keloid scars reached the minimum values and equaled to 66.8 (68.9 in women, 63.2 in men) (Table 2). This fact indicates a possible “infiltrative” type of cellulose rumen growth, which is confirmed by morphological studies [*Avetikov D, Stavytsky S, 2012*].

Treated tissues rumen echogenicity indices

Table 2

Distribution of keloid scar echogenicity indices in ultrasound examination

Observation	T1	T2	T3	T4	L1	L2	L3	L4	L1/2	L3/4
1	68	57	61	55	58	67	58	65	0.87	0.89
2	64	52	58	49	53	69	54	61	0.77	0.88
3	71	61	67	56	52	61	63	70	0.85	0.90
4	62	51	59	46	45	72	55	62	0.62	0.88
5	70	52	62	48	52	58	57	66	0.89	0.86
6	58	49	53	44	46	56	52	57	0.82	0.91
7	72	58	64	51	53	73	61	69	0.73	0.88
8	67	56	61	49	45	64	59	64	0.70	0.92
9	69	50	58	43	49	63	53	62	0.77	0.85
10	61	46	56	41	43	59	49	60	0.73	0.81
11	58	49	52	44	47	56	52	57	0.84	0.91
12	71	58	53	52	49	64	63	59	0.77	1.06
13	74	62	59	57	58	66	65	64	0.88	1.01
14	66	49	61	53	52	62	53	66	0.84	0.80
15	72	59	63	61	65	68	62	69	0.95	0.90
Medium value	66.8	53.9	59.1	49.9	51.1	63.8	57.1	63.4	0.81	0.89

along the periphery of the rumen were significantly lower in all studied groups and amounted to 53.9 in the medial margin (55.4 in women, 49.7 in men); in the lateral region they ammonted to 59.1 (61.9 in women, 56.1 in man). The smallest echogenicity index was recorded in the middle zone of the rumen and amounted to 49.9 (53.8 in women, 44.2 in man), which indicates the greatest tissue density of keloid scars.

The most controversial data were obtained in determining the values of the echogenicity rates between the scarred tissues with epidermis and hypodermis. The difference in indices was the minimum values of 51.1 (53.8 in women, 47.6 in men) and 63.8 (65.2 in women, 59.8 in men) respectively. Differences in the echogenicity of the tissues at the border between intact derma and medial and lateral edges of the rumen were obtained. This difference reached the maximum values and amounted to 57.1 (in women 61.8 men 53.2) and 63.4 (65.3 and 61.1, in women and men respectively). Obviously, this discrepancy is due to the heterogeneity of connective tissue structures along the periphery, which, in our opinion, is an important feature in the primary diagnosis of keloid scars, especially in the early stages of their formation. The study of L1/2, L3/4 indices has proved the identity of the digital data with their minimal differences (0.81 and 0.89 respectively), indicating a decrease in the echogenicity level, both in the middle zone and in the peripheral tissues of keloid scars, which, in our opinion, the difference in ultrasound examination.

Discussion

Analyzing echogenicity indicators qualitative data of the intact skin, scar tissue, areas of limitation of various scar groups in different layers of the skin, one can conclude that each group of scar tissue has its own geometric features that emphasize the affinity of tissue to a certain group of scar with their optical imaging.

In the analysis of quantitative data, a similar picture is observed. The digital values of echogenicity indices in different parts of all scar groups were investigated and the differences in their quantitative characteristics were determined. It should be noted that the digital characteristic of variational series of echogenicity indicators obtained at certain points may indicate to the correlation between the scar density in different zones, the degree of its echogenicity at these points and its affiliation to a certain type of scar. It should be noted that ultrasound revealed a gram of pathological scars in comparison

with the intact skin has its own geometric features, which emphasize the affiliation of tissue to a certain group in optical imaging. Thus, we have established the digital values of echogenicity indices in different sites of pathological scar and differences in their quantitative characteristics when compared to the intact skin. Obtained results of the study extend the possibilities of pathogenetically grounded treatment of the patients with head and neck pathological scars and also make it possible to use this diagnostic complex to assess the dynamics of changes during scar tissue correction.

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