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І МЕДИЦИНИ**

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*Тыхонова О. О., Шерстюк О. О., Тарасенко Я. А.,
Білаш В. П., Сербін С. І., Дубина С. О., Ткаченко О. Т.***TYPICAL MORPHOLOGICAL CHARACTERISTICS OF THE SKIN STRUCTURE OF THE HAIR
PART OF THE NORMAL HUMAN HEAD AND WITH HAIR LOSS**¹**Poltava State Medical University (Poltava, Ukraine)**²**Donetsk National Medical University (Kropyvnytskyi, Ukraine)**tykhonova.olesia@gmail.com

A research object is the shreds of skin of hairy region of head of human with a hair cover which was saved, and at the distinctly expressed phenomena of androgenic alopecia, and also tissue complexes of membranous skull of 5-month fetuses of human.

It is set as a result of research, that in the skin of hairy region of head of human there are different populations of hair follicles, which differs in depth bedding of the root bulbs and by a tendency to the united association in triads, that is conditioned genetically and especially model expressed on the 5th month of fetal period.

Complete loss of hairs due androgenic alopecia, points the skins of hairy region of head leads to compensatory reorganization, which is expressed in a substitution in the hypodermis of loose fibred connecting tissue by fatty tissue, vast excrescence in all layers skins of blood vessels, which the venous prevail among, and also in the considerable increase of concentration of sebaceous glands in the reticulated layer of derma.

Key words: hair follicles, androgenic alopecia, scalp, germinal elements.

Connection of the publication with planned research works.

This study is part of the research project “Morpho-functional study of human internal organs and laboratory animals in various aspects of experimental medicine”, state registration number 0121U108258.

Introduction.

According to the classification of hair diseases, they are divided into congenital and acquired, alopecia may be scarring and non-scarring, focal and diffuse [1, 2].

One of the well-known symptoms is diffuse hair loss, which is a characteristic feature of some nosological forms of alopecia. Diffuse hair loss (hair thinning) accompanies such pathological conditions as acute or chronic telogen loss, anagen alopecia, androgenic alopecia, a number of genetic diseases [1].

Androgenic alopecia is characterized by baldness in the frontal and parietal areas in men, which is associated with genetically determined disorder of androgen metabolism in the skin of the scalp heads. Androgenic alopecia belongs to autosomal dominant disorders with variable penetrance to the same degree in men and women. Progressive hair loss leads to gradual miniaturization of the hair follicle and shortening of the anagen phase [1, 3].

The above-mentioned facts determine the relevance of our research.

The aim of the study.

The aim of our research was to reveal the regularities of the structural organization of the skin of the scalp of men in normal conditions and the nature of its restructuring in the process of androgenic hair loss.

Object and research methods.

In the course of our research, the following morphological methods were used: methods of epoxy plastination of large pieces of skin; production of lamellar polished cuts and their coloring with methylene blue; study of polished sections using a binocular magnifier and a light microscope in reflected and transmitted light [4, 5, 6, 7, 8].

The collection of material was carried out in Poltava Oblast patho-anatomical bureau of the Poltava Regional Council (PRC) and in the patho-anatomical department of Poltava Regional Clinical Psychiatric Hospital named after O.F. Maltseva within the framework of cooperation agreements with Poltava State Medical University (PSMU).

The work was carried out in accordance with the requirements of the “Instructions on conducting a forensic medical examination” (order of the Ministry of Health of Ukraine No. 6 dated from 17.01.1995), in accordance with the requirements and norms, the standard regulation on ethics of the Ministry of Health of Ukraine No. 690 dated from 23.09.2009, “The procedure for removing biological objects from the dead, whose bodies are subject to forensic medical examination and patho-anatomical examination, for scientific purposes” (2018).

Research results.

In the course of the study, it was established that in the hairy part of the human head, the hypodermis is an inseparable part of the skin, not only because it firmly connects the dermis with the tendinous helmet of the vault of the head, but also because its environment has the necessary conditions for the matrix structures of the majority of hair follicles. For comparison with bald skin, it should be taken into consideration that the hypodermis of normal skin is mainly represented by loose fibrous connective tissue, the main volume of which is gel-like amorphous substance. It is possible that this environmental factor contributes to the functioning of hair follicles and delays their degradation during the process of baldness.

Considering the fact that hair follicles pass through the reticular layer of the dermis, the planar sections obtained by us allow to conclude that it is an ethmoid (or sieve-like) structure with cross-sectional polygonal cells located in a cluster order, which are occupied by hair follicles and structures, which refer to them. The nature of the distribution of these follicular cells in the dermis corresponds to the order of distribution on the surface

of the epidermis of hair follicles. It was also possible to predict that hair loss with alopecia will inevitably lead to the loss of the reticular layer of its normal cellular structure.

As everybody knows, the layer of thin fibrous connective tissue called the papillary layer is traditionally referred to the dermis. In the composition of the skin, it has its functional significance, which contains both distinguishing different tissue structures from each other, and performing an intermediary role between them, mainly providing exchange processes between blood microvessels and epithelial formations, such as the epidermis and its derivatives (hair follicles, sebaceous and sweat glands). The proof of this theory can be the fact that due to this sub-epithelial thin fibrous layer, not only the connective tissue papillae of the epidermis are formed (from which the name of this layer comes), thanks to which the area of the contact of the epithelial cover with the underlying trophic base is significantly increased. The sebaceous and sweat glands connective tissue membranes that grow around the hair follicles, in the stroma of which exchange blood microvessels are embedded also confirm this approach. It is important that such membranes around hair follicles are described in the literature under the name of hair bags. According to our data, normally there is always a thin interstitial gap between the hair follicles and the connective tissue framework of the reticular dermis.

In the research, we could not help but pay attention to some features of the predominant location of individual blood vessels of the skin of the scalp. Most often, blood vessels are found in three stratification zones. The first of them includes the boundary between the hypodermis and the tendon helmet. The second is the reticular layer of the dermis, where the largest blood vessels are most often located and the constant regeneration of the epidermis itself is carried out. The third zone is represented by the subepithelial, papillary layer on the border with the reticular layer of the dermis. Our observations allow us to say that the hemomicro-circulatory channel of hair follicles originates only from the superficial, subepithelial blood plexus, embedded, as mentioned above, in the thin fibrous stroma of the papillary layer, which is the source of the formation of connective tissue membranes of all skin derivatives. By the way, this coincides with the stages of hair follicle formation in embryogenesis. We will recall that this process begins with the gradual growth of epithelial strands from the germinal epidermis into the thickness of the underlying mesenchyme. We have shown that in the 5th month of intrauterine life, primitive blood vessels in the form of a looped mesh are located only near the epidermis. Therefore, microvessels can depart only from them along the course of developing hair follicles, up to the connective tissue papillae of their root bulbs.

In our opinion, when assessing the functional aspects of the hairy skin of the head, as well as to understand the nature of hair loss in baldness, it is worth taking into account the well-known fact that the basal layer of this epithelial layer is represented by stem cells that have the potential to differentiate in at least four directions. First of all, due to them, the constant regeneration of the epidermis takes place. The second branch of their differentiation is the formation of the epithelial association of hair follicles in the form of their outer and inner

sheath. It is essential that in one or another version, their determining elements are horn cells – keratocytes, which in the first case simply peel off from the surface of the epidermis, and in the second they are organized into complex formations, which are hair. The third and fourth lines of differentiation of basal epitheliocytes are aimed at the formation of secretory structures represented by sebaceous and sweat glands. We draw attention to the fact that the sebaceous glands in the scalp are connected by short isthmuses directly to the epithelium of the outer sheath of the hair follicles. In the future, this will help us understand some features of the structural changes that occur in the skin during the process baldness. In addition, the undoubted fact of cytogenetic affinity between the epidermal epithelium and its derivatives should attract attention to itself, if we consider that the basis of androgenetic alopecia is a hereditary factor.

It has been found out that in the skin of the scalp of men there are different populations of hair follicles, which differ among themselves primarily by the depth of their root bulbs and the tendency to unite in pairs and triads. The presence of clear morphological signs of certain differentiation and regular ordering of matrix structures of hair in the skin is genetically determined, as evidenced by the results of our study of embryonic skin. This morphogenetic feature is demonstrably expressed in the 5th month of intrauterine development. During this period, there are fully formed hair follicles in the skin of the parietal area, which, like in an adult, are located in the regular order at an angle to the surface of the epidermis. The fact that the root bulbs occupy different depths in such a way that among them the deep, middle and surface rows stand out. The second remarkable feature, which persists in postnatal life, is that the hair follicles in the embryonic skin are not located separately, but are distributed along the hairline in separate triads, and each triad consists of one, centrally located, thick follicle and two lateral satellite ones, which differ from the first one by a smaller diameter. The root bulbs of thick hair follicles centrally located in triads are situated in that layer of the embryonic skin, which is embryonic for the hypodermis. Satellite follicles join it in the surface layer. In order to further clarify some features of terminal hair and its transformation in the process of baldness, it should be taken into consideration that embryonic hair (lanugo), although much thinner than terminal hair, is similar to it in its thickness. So, relatively thick, medium-thick and thin hairs are clearly distinguished. At the same time, the thickness of hair is directly dependent on the depth of the root bulbs. Comparative metric data on hair thickness are shown in **table**.

Naturally, in the skin of an adult, such a picture is largely hidden due to the greater density and complexity of the composition of the structures that form it. However, during a careful layer-by-layer study of epoxy grindings, the main morphogenetic features noted above can be recognized. In any case, two types of hair follicles stand out in the thickness of the skin of the scalp. According to some considerations, which will be explained later, those whose root bulbs are contained in the deep layer of the hypodermis should be referred to the first type, in connection with which we distinguish them by the name of **hypodermal** hair follicles. As for the second type, the location of the root bulbs is the

mesh layer of the dermis, which is the basis for classifying them as superficial, **intra-dermal** hair follicles. It should be emphasized that the first (hypodermal) hair follicles are the source of thick hair, while the second produce medium-thick and thin hair (table 1). Consequently, the thickness of the hair is directly dependent on the depth of its matrix in the skin, i.e. the thicker the hair, the deeper its matrix is. As it will be shown later, the hair with deep lying in the hypodermis of its matrices is the most resistant to the degradation process during baldness.

It should be taken into consideration that there is no information in the literature with which the facts given by us could be compared, but the fact that they are completely objective can be further confirmed by considering the results of our research on the skin of the scalp in the case of androgenic bald. In the same aspect, the fact (not mentioned in the literature) that among intradermal hair follicles normally with regular stability, although infrequently, there are fused (doubled and tripled) follicular formations, which, as a rule, have separate root bulbs is of particular interest. Similar to their fused parts are the hair follicle and the epithelium of the external vagina. By the inner sheath, they are divided into two or three cases for individual hair (usually thin and medium in thickness). As it will be proved later, such follicular aberrations become common for alopecia.

The uneven thickness of hair we found in the well-preserved scalp of men can be treated as a manifestation of age-related degradation of hair follicles. The results of our research demonstrate that the hair cover of the human head normally consists of hair of different thickness, among which thick, thin and medium thickness can be differentiated (table 1). The last two types are distributed among themselves and mixed among the shafts of thick hair, which determine the nature of the shape of the hairlines on the scalp. In order to finally make sure of this, we started an introductory study of the hair of young men.

Without going into details, it is necessary to underline the most important facts. First of all, the hair cover of young men is a mixture of hair of different thicknesses (from their very roots to the ends), among which the thick ones predominate quantitatively. In old age, the presence of thin hair among thick hair cannot be interpreted as a manifestation of the degradation of a certain part of the hair follicles.

In contrast to the data of the literature, the results of our research indicate the presence of brain substance in part of the shaft hair. It is interesting that it does not depend on its thickness, in connection with which, among all shaft hairs, those with and those without medulla stand out, which are in approximately equal partial correlation. If we consider that it is also typical for the root part of the hair, then one can make the following conclusion: there is a similar difference between the hair follicles in the skin of the scalp. It is quite possible that the brain substance does not determine the full-fledged properties of the hair at all. If it is really so, then it is worth asking questions about the functional purpose of the hair that contains it.

Table – Summary data on the thickness of the shaft hair of the scalp human head

Hair type	Hair caliber, μm			
	thick	medium thickness	thin	literature data
Embryonic (lanugo) 5 months old fetus	from 36,2 to 57,8	from 29,8 to 31,5	from 12,8 to 17,9	from 20 to 40
The terminal of an adult	from 89,5 to 112,3	from 67,0 to 84,8	from 43,6 to 45,1	from 64,5 to 96,4
Abortive hairs in the bald area	from 30,8 to 38,0	from 24,7 to 26,9	from 14,8 to 15,7	Absent

At this time, the cause of “normal” asymptomatic alopecia is considered to be an increase in androgen hormones (testosterone) in the blood. However, many authors believe that this factor acts only under conditions of hereditary predisposition, that is, the effect of the gene is realized only under the influence of androgenic hormones [9, 10]. At present, in general, the hereditary predisposition to the occurrence and progression of various diseases is considered from the point of view of the action of genes [11].

It is mentioned in the literature that the male sex hormone in the form of dihydrotestosterone sensitizes the root bulbs of hair follicles and sebaceous glands. It is interesting to know to which factor their sensitivity increases. There is no answer to this question in the literature. The mechanism of the destructive effect of testosterone on hair follicles is still unknown.

The obtained results show that, indeed, the process of baldness in general does not leave behind pathologically changed skin; it undergoes reconstruction, which is in compensating for lost hair. The results of our research indicate the presence of stagnant phenomena in the venous channel of the skin of the hairy part of the head in case of alopecia.

The most complete picture of the variety of structural changes that occur in the skin during androgenic alopecia is shown by the scalp area, which is the transition between the completely exposed area and the remaining hair cover. In this zone, first of all, the fact that the root bulbs of largely thinned, but intact hair follicles are located in the thickness of the skin at different depths not only in the hypodermis, but also in the reticular layer of the dermis draws attention. As a result there is general impression that some of the hypodermal root bulbs are shifted to the surface due to the shortening of another part of the hair follicle.

Some clarification of the reason for the degradation of hair follicles in androgenetic alopecia is given by the data that the sclerosing of the reticular layer of the dermis, which is in the replacement of degraded hair follicles with connective tissue, leads to its dense overgrowth of the remaining hair follicles. Due to this fact, it is observed in isolation from the free interstitial space, which normally, in the form of a gap, separates the connective tissue hair bag of the follicle from the stromal elements of the reticular layer of the dermis. Along with those sclerotic changes, the hair follicles themselves are exposed to their thickening and replacement of thin collagen fibrils with thick bundles, which is accompanied by the obliteration of blood capillaries in them. It is clear that all these factors significantly impair the trophicity of the follicular epithelium, which, according to our data, undergoes homogenization. As a result of these

changes the boundary between their outer and inner sheaths disappears in many remaining hair follicles.

One of the interesting phenomena occurring in the skin with androgenic alopecia is the increased formation of aggregated hair follicles. As it has been mentioned before, they have a common hair-sac and common external epithelial sheath, while several of the root hairs which they contain are in the core of separate internal sheaths.

At the same time, in the reticular layer of the dermis of the transitional zone of the scalp during alopecia, follicles of minimum sizes are found with regular consistency. They are located in close proximity to ordinary or aggregate hair follicles, which is very reminiscent of the embryonic type of root hair distribution, which was mentioned above. It is important that these satellite follicles, as in the embryonic skin, contain the thinnest root hair. Most likely, satellite follicles, which are the source of the formation of fine hairs, appear in the skin during baldness as a result of the disorder of the proliferative differentiation of the follicular epithelium during the beginning of a new cycle (anagen phase) of hair growth. Obviously, in the transitional zone with baldness, the potential ability to restore hair gradually decreases, but has not been completely exhausted yet.

Our assumption that the hair follicles located in the reticular layer of the dermis are the result of the degradation of those follicles whose root bulbs are embedded in the hypodermis can be supported by the fact that in the border zone between the completely bald skin and the transition zone presented above, the reticular dermis turns out to lack hair follicles completely. And there are only occasional single follicles, the root bulbs of which are embedded deep in the hypodermis. It is necessary to mention that they are the source of the formation of thick hair. However, this assumption cannot be undisputable, because we do not have the necessary data on the dynamics of hair growth and hair loss. The data of the literature, which do not at all relate to the fact that the most favorable conditions for hair matrices (as germinal structures represented by root bulbs and their connective tissue papillae) have the hypodermis, do not bring any clarity to the solution of this issue. Therefore, basing on the results of our own research, we came to the conclusion that the best place for hair matrices in the skin in the hypodermic part of the human head is hypodermis. It can be assumed that some of its connective tissue elements have inductive properties that contribute to the deep germination of hair follicles. It is quite possible that in androgenic alopecia, the expressed "baldness genes" lead to the blocking of the process of production by connective tissue cells of the hypodermis of certain substances that have properties that activate the proliferation of the follicular epithelium.

Discussion of research results.

In our study, we were most interested in androgenic alopecia. The process that develops with it leads to a complete loss of hair in the affected areas of the scalp, leaving behind, as mentioned above, changed skin that is adapted to perform its function at the expense of other properties. This compensatory and adaptive restructuring is carried out mainly due to the physiological hypertrophy of the main tissue components of the skin. Thus, in the hypodermis, loose fibrous tissue is replaced

by adipose tissue, which should be aimed at increasing the heat-insulating properties of the skin. A similar effect, as well as the improvement in the protection of the epidermis, should lead to a significant increase in the concentration of sebaceous glands, for which the mouths of the excretory ducts serve as former hair watering cans. But due to the fact that the growth of sebaceous glands occurs due to the reduction of the connective tissue stroma of the reticular layer of the dermis, the mechanical strength of the skin as a whole should decrease. Complete loss of hair in androgenic alopecia causes an increased blood supply in the skin due to the large growth of blood vessels in all layers of the skin, in which venous vessels are partially predominant. The ability of the these vessels to accumulate a large volume of blood during its shunting inflow should be an important link in the implementation of thermoregulation mechanisms. In general, after hair loss in androgenic alopecia, such skin rearrangement is genetically predicted, which helps to preserve its protective properties.

At the same time, one cannot help but draw attention to the fact known from the literature that (as some authors write) "even a bald person's head is covered with thin down, as if the hair follicles have become tiny and form tiny hairs" [12, 13]. It is customary to characterize them as embryonic or downy hair. In terms of thickness, they are indeed comparable to the first ones (table 1.). But the results of our research do not give grounds to attribute them to one or the other type, because both embryonic hair and downy hair (which covers other parts of the body) have fully developed hair follicles in the skin. According to our data, hair elements that appear in the skin of the scalp after baldness do not have hair follicles as such. Their germinal epithelial rudiments are hidden in the thickness of the sebaceous glands. Due to the fact that they appear as a result of the degeneration of previous hair follicles, we consider them to be abortive elements. The question is whether their germinal sources retain the capacity for full regeneration. At the moment, this issue is not discussed in the literature.

Conclusions.

In the course of our research, we have made the following conclusions:

In the skin of the scalp of men, there are different populations of hair follicles, which differ in the depth of the root bulbs and the tendency to combine in triads, which is determined genetically, and is especially vividly expressed in the 5th month of fetal life.

Hair follicles are divided into two types according to their location: hypodermal and intradermal. Most of them are those whose root bulbs are in the hypodermis. The second type consists of few follicles. Due to the fact that their root bulbs are located in the cells of the reticular layer of the dermis, they are called intradermal.

The thickness of the hair is directly dependent on the depth of its root bulb (matrix) in the skin. The thicker the hair, the deeper its root bulb is. Hair with a deep deposit in the hypodermis of the root bulbs is the most resistant to androgenic alopecia.

Among intradermal hair follicles, doubled and tripled formations are normally observed, but they have separate root bulbs. A hair bag and an external epithelial sheath are common for their fused parts. By the inner

sheath, they are divided into two or three cases for individual hair, respectively.

The hair cover of the head of men normally consists of hair of different thicknesses, among which the thick ones prevail (from 89.5 to 112.3 microns). Thin (from 43.6 to 45.1 μm) and medium (from 67.0 to 84.8 μm) hair thickness is distributed among the shafts of thick hair, which determine the nature of the shape of hairlines on the scalp.

In the process of androgenic alopecia, the intradermal hair follicles, in which sclerosing of hair follicles is observed, undergo degradation. This process is accompanied by increased formation of aggregate (doubled and tripled) hair follicles. In the reticular layer of the dermis, degenerating hair follicles are replaced by connective tissue. The first signs of sebaceous gland hypertrophy are observed.

Complete loss of hair in androgenic alopecia leads to compensatory and adaptive restructuring of the skin

of the scalp, which is expressed in the replacement of loose fibrous connective tissue in the hypodermis by adipose tissue, a large growth in all the layers of the skin of blood vessels, among which venous ones predominate, as well as in a significant increased concentration of sebaceous glands in the reticular layer of the dermis.

Despite the complete loss of hair in androgenic alopecia, germinative epithelial elements are preserved in the skin of the scalp, which are the sources of the formation of thin (abortive) hairs, the matrix structures of which are hidden in the thickness of the sebaceous glands.

Prospects for further research.

The obtained data on the established features of the structure of the skin of the scalp of men in normal conditions and with androgenetic alopecia can be used in practical health care (dermatovenerology) to optimize the ways of overcoming the specified medical problem.

References

1. Kalyuzhna LD, Hrechans'ka LV, Petrenko AV. Systemna pidtrymka formuvannya ta rostu volossya pry alopetsiyakh i zakhvoryuvannyakh stryzhnyya volosyny. Dermatolohiya ta venerolohiya. 2020;2:29-34. [in Ukrainian].
2. Ruk A, Dauber R. Bolezni volos i volosistoy chasti golovy. M: Meditsina; 1985. 528 s.
3. Drake LA, Dinehart SM, Farmer ER, Goltz RW, Graham GF, Hordinsky MK, et al. Guidelines of care for androgenetic alopecia. American Academy of Dermatology. J Am Acad Dermatol. 1996 Sep;35(3.1):465-9.
4. Bahriy MM, Dibrova VA, Popadynets' OH, Hryshchuk MI. Metodyky morfolohichnykh doslidzhen'. Vinnytsya: Nova knyha; 2016. 328 s. [in Ukrainian].
5. Belokon' SA, Vitko YuN, Tkachenko PI, Starchenko II, Hryn VH. Optimizatsiya issledovaniya strukturnykh elementov biologicheskikh tkaney na gistotopograficheskikh shlifakh. Molodoy uchenyy. 2014;15(74):134-7.
6. Hryn VH, Sherstyuk OO, Starchenko II, Pryluts'kyy OK, vynakhidnyky; VDNZU «UMSA», patentovlasnyk. Sposib kompleksnoho morfolohichnoho doslidzhennya chervopodibnykh vidrostkiv lyudyuy v epoksydnyy smoli «EPON-812». Patent Ukrayiny na korysnu model' № UA112472U. 2016 Hrud 26. [in Ukrainian].
7. Kostilenko YuP, Kovalov YeV. Metody raboty s polutonkimi epoksidnymi srezami v gistologicheskoy praktike. Arkhiv anatomii, gistologii i embriologii. 1978;75(12):68-72.
8. Kostilenko YuP, Boyko IV, Starchenko II. Metod izgotovleniya gistologicheskikh preparatov, ravnotsennykh polutonkim srezam bol'shoy obzornoy poverkhnosti, dlya mnogotselevykh morfolohicheskikh issledovaniy. Morfologiya. 2007;5:94-6.
9. Kaufman KD. Androgen metabolism as it affects hair growth in androgenetic alopecia. Dermatol Clin. 1996 Oct;14(4):697-711. DOI: [10.1016/s0733-8635\(05\)70396-x](https://doi.org/10.1016/s0733-8635(05)70396-x).
10. Nestor MS, Ablon G, Gade A, Han H, Fischer DL. Treatment options for androgenetic alopecia: Efficacy, side effects, compliance, financial considerations, and ethics. J Cosmet Dermatol. 2021 Dec;20(12):3759-3781. DOI: [10.1111/jocd.14537](https://doi.org/10.1111/jocd.14537).
11. Shkodina AD, Tan SC, Hasan MM, Abdelgawad M, Chopra H, Bilal M, et al. Roles of clock genes in the pathogenesis of Parkinson's disease. Ageing Res Rev. 2022 Feb;74:101554. DOI: [10.1016/j.arr.2021.101554](https://doi.org/10.1016/j.arr.2021.101554).
12. Chen W, Yang CC, Tsai RY, Liao CY, Yen YT, Hung CL, et al. Expression of sex-determining genes in the scalp of men with androgenetic alopecia. Dermatology. 2007;214(3):199-204. DOI: [10.1159/000099583](https://doi.org/10.1159/000099583).
13. Chuong CM. Regenerative biology: new hair from healing wounds. Nature. 2007 May 17;447(7142):265-6. DOI: [10.1038/447265a](https://doi.org/10.1038/447265a).

ТИПІЗОВАНА МОРФОЛОГІЧНА ХАРАКТЕРИСТИКА БУДОВИ ШКІРИ ВОЛОСИСТОЇ ЧАСТИНИ ГОЛОВИ ЛЮДИНИ У НОРМІ ТА ПРИ ВТРАТІ ВОЛОССЯ

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Резюме. Метою нашого дослідження було встановлення закономірностей структурної організації шкіри волосистого відділу голови чоловіків у нормі й характер її перебудови у процесі андрогенної втрати волосся.

Об'єкт і методи дослідження. Для досягнення поставленої мети ми використовували комплекс методів для морфологічних досліджень: способи епоксидної пластинації великих шматків шкіри; виготовлення пластинчастих полірованих шліфів та їхнє забарвлення метиленовим синім; їх вивчення за допомогою бінокулярної лупи й світлового мікроскопа у відбитому та прохідному світлі.

Результати дослідження та їх обговорення. Отримані нові дані, які розширюють і поглиблюють сучасні уявлення про будову шкіри волосистої частини голови людини й характер її перебудови при облісінні. Уперше показано, що у процесі андрогенної втрати волосся впливу деградації зазнають у першу чергу інтрадермальні волосяні фолікули. Цей процес супроводжується утворенням агрегатних волосяних фолікулів.

Повна втрата волосся при андрогенній алопеції призводить до компенсаторно-приспосувальної перебудови шкіри волосистого відділу голови, що виражається заміщенням у гіподермі пухкої сполучної тканини жировою тканиною, розростанням у всіх шарах шкіри кровоносних судин, серед яких превалюють венозні, а також у збільшенні концентрації сальних залоз у сітчастому шарі дерми.

Доведено, що незважаючи на повну втрату волосся при андрогенній алопеції у шкірі волосистого відділу голови мають місце гермінативні епітеліальні елементи, які є джерелом утворення тонкого (абортивного) волосся, матричні структури яких сховані у товщі сальних залоз.

Висновки. Отримані результати не тільки доповнюють відомі факти, але й більш глибоко розкривають принципи морфологічної будови шкіри волосистого відділу голови чоловіків у нормі й після андрогенного облісіння.

На основі одержаних фактичних даних обґрунтовується положення, відповідно до якого втрата волосся при андрогенній алопеції не призводить до патологічної зміни шкіри, а компенсується за рахунок фізіологічної гіпертрофії інших її тканинних складових.

Ключові слова: волосяні фолікули, андрогенна алопеція, волосиста частина голови, гермінативні елементи.

TYPICAL MORPHOLOGICAL CHARACTERISTICS OF THE SKIN STRUCTURE OF THE HAIR PART OF THE NORMAL HUMAN HEAD AND WITH HAIR LOSS

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Abstract. *The aim of our research* was to reveal the peculiarities of the structural organization of the skin of the scalp of men in normal conditions and the nature of its restructuring in the process of androgenic hair loss.

Object and research methods. To achieve the goal, we used a set of methods for morphological studies: methods of epoxy plastination of large pieces of skin; production of lamellar polished cuts and their coloring with methylene blue; their study using a binocular magnifier and a light microscope in reflected and transmitted light.

Research results and their discussion. New data were obtained, which expand and deepen modern ideas about the structure of the skin of the hairy part of the human head and the nature of its reconstruction during baldness. It has been shown for the first time that in the process of androgenic hair loss, intradermal hair follicles are primarily affected by degradation. This process is accompanied by the formation of aggregated hair follicles.

Complete loss of hair in androgenic alopecia leads to a compensatory and adaptive restructuring of the skin of the scalp, which is expressed by the replacement of loose connective tissue in the hypodermis with adipose tissue, the growth of blood vessels in all the layers of the skin, among which venous ones prevail, as well as in the increase in the concentration of sebaceous glands in the reticular layers of the dermis.

It has been proven that despite the complete loss of hair in androgenic alopecia, germinal epithelial elements are present in the scalp skin, which are the source of the formation of thin (abortive) hair, the matrix structures of which are hidden in the thickness of the sebaceous glands.

Conclusions. The obtained results not only supplement the known facts, but also more deeply reveal the principles of the morphological structure of the skin of the scalp of men in normal conditions and after androgenic alopecia.

On the basis of the received factual data, the position is substantiated, according to which hair loss in androgenic alopecia does not lead to pathological changes in the skin, but is compensated by the physiological hypertrophy of its other tissue components.

Key words: hair follicles, androgenic alopecia, scalp, germinal elements.

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The authors declare no conflict of interest.

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