PHOTODYNAMIC THERAPY OF ACNE

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Abstract

Acne is one of the most common skin conditions in the world. A number of studies have shown that photodynamic therapy (PDT) is safe and effective for both inflammatory and non-inflammatory acne and can significantly improve skin conditions in this disease. The effectiveness of PDT against acne is mainly due to a decrease in the amount of sebum produced by the sebaceous glands due to a decrease in their activity as a result of direct photodynamic damage to the sebaceous glands, eradication of Cutibacterium acnes, and a decrease in the level of hyperkeratosis. Compared with systemic drug therapy, PDT treatment of severe acne has the following advantages: fast results, high efficiency, high selectivity, no systemic adverse reactions and drug resistance, and low recurrence rate. Most often for PDT in patients with acne, drugs based on 5-aminolevulinic acid (5-ALA) and its methyl ester (ME-ALA) are used. At the moment, there are no unified recommendations on PDT regimens for the treatment of this skin pathology. Various studies demonstrate the high efficiency of PDT with a wide range of doses of 5-ALA (3-20%) and ME-ALA (4-16%), light doses (15-120 J/cm^2), and exposure time (30-90 min). The general trend in studies by different authors is that gentle low-intensity PDT regimens for acne demonstrate the same high efficiency with a significant reduction in pain during irradiation and local skin reactions (erythrema, edema, and hyperpigmentation).

Key words: photodynamic therapy, acne, 5-aminolevulinic acid, 5-aminolevulinic acid methyl ester.

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ФОТОДИНАМИЧЕСКАЯ ТЕРАПИЯ ПРИ АКНЕ

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Резюме

Акне – одна из самых распространенных в мире кожных патологий. Ряд исследований показал, что фотодинамическая терапия (ФДТ) безопасна и эффективна при воспалительной и невоспалительной форме акне и может значительно улучшить состояние кожи при этом заболевании. Эффективность ФДТ против акне в основном обусловлена уменьшением количества кожного сала, вырабатываемого сальными железам, за счет снижения их активности в результате прямого фотодинамического повреждения сальных желез, эрадикацией *Cutibacterium acnes* и снижением уровня гиперкератоза. По сравнению с системной медикаментозной терапией лечение тяжелой формы акне методом ФДТ имеет следующие преимущества: быстрый результат, высокая эффективность, высокая селективность, отсутствие системных побочных реакций и лекарственной устойчивости, низкая частота рецидивов. Наиболее часто для ФДТ у больных акне применяют препараты на основе 5-аминолевулиновой кислоты (5-АЛК) и ее метилового эфира (МЭ-АЛК). На данный момент не существует единых рекомендаций по режимам ФДТ для лечения данной кожной патологии. Различные исследования демонстрируют высокую эффективность ФДТ с широким диапазоном доз 5-АЛК (3-20%) и МЭ-АЛК (4-16%), световых доз (15-120 Дж/см^2) и времени облучения (30-90 мин). Общая тенденция в исследованиях разных авторов сводится к тому, что щадящие низкоинтенсивные режимы ФДТ при акне демонстрируют такую же высокую эффективность при значительном снижении болевых ощущений в процессе облучения и местных кожных реакций (эритрема, отек, гиперпигментация).

Ключевые слова: фотодинамическая терапия, акне, 5-аминолевулиновая кислота, метиловый эфир 5-аминолевулиновой кислоты.

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Acne (acne vulgaris) is a chronic inflammatory skin disease characterized by overgrowth of the microorganism Cutibacterium acnes, formerly known as Propionibacterium acnes, in the sebaceous glands [1].

Epidemiology

Acne affects approximately 600 million people worldwide every year, making it the eighth most common skin disease in the world [1]. Acne occurs in 70-75% of prepubertal children up to 12 years of age (usually at 9-11 years of age). Up to 80-85% of teenagers and young adults suffer from acne. In older age groups, the percentage decreases, but still, almost one in ten adults over 25 suffers from acne [2]. Although acne is not a life-threatening disease, serious psychological consequences have been reported in various studies in patients, which can affect sociability, cause phobias, and lead to depressive symptoms [1].

Etiology and pathogenesis

Acne can occur against the background of seborrhea, which is characterized by a change in the chemical composition of sebum and increased secretion of sebum by the sebaceous glands. As a result, acne occurs in areas of the skin that are richest in sebaceous glands [2]. Acne pathogenesis involves four main mechanisms: follicular hyperkeratosis (epithelial proliferation with thickening of the stratum corneum of the sebaceous gland channels), increased secretion of sebum, *C. acnes* colonization, and localized inflammation [3]. It is believed that it is the colonization of *C. acnes* that plays a key role in the development of acne [3]. *C. acnes* is a Gram-positive, anaerobic, slow growing bacterium that metabolizes triglycerides and produces cytokines that induce inflammatory responses [3,4].

Classification

According to the ICD-10 classification, the following types of acne are distinguished: L.70.0 Acne vulgaris; L.70.1 Acne globose; L.70.2 Smallpox acne; L.70.3 Tropical eels; L.70.4 Children acne: L.70.5 Excoriated acne; L.70.8 Other acne and L.70.9 Acne unspecified. There is also a classification of acne vulgaris according to the type of lesions: 1. Non-inflammatory acne: closed and open comedones; 2. Inflammatory acne (superficial: papulopustular; deep: indurative, conglobate; complicated: nodular cystic, abscessing, phlegmonous, keloid, scarring, complicated by sinus tracts) [2].

The Leeds acne severity score takes into account acne lesions on the face, back, and chest and classifies them as inflammatory or non-inflammatory. Leeds scores range from 0 (least severe) to 10 (most severe). There are modified Leeds scales, the maximum score for which is 12 [5,6]. The Pillsbury Acne Rating Scale ranks acne severity from 1 (least severe) to 4 (most severe) [7,8].

Acne therapy

Traditional acne therapy includes topical and systemic antibiotics, such as tetracyclines and isotretinoin, as well as retinoids [1]. The use of antibiotics is significantly limited by the growth of antibiotic resistance in *C. acnes*, and the use of retinoids is limited by their serious side effects associated with teratogenicity, spontaneous abortion, skin irritation, cheilitis, photosensitivity, arthralgia, hypertriglyceridemia, inflammatory bowel disease, pancreatitis, and depression [3,9]. Acne therapy is very long. Thus, according to Cunliffe *et al.*, for complete resolution of mild to moderate acne, 3–4 years of treatment are required, and in the case of severe acne, 8–12 years may be required. According to Cunliffe, in 7% of patients with disease manifestation in adolescence, the manifestations of the disease can last up to 45–50 years [10]. Long-term use of antibiotics can cause a variety of side effects, including dysbiosis and an increased chance of infection with opportunistic pathogens. Long-term use of isotretinoin can cause dry skin and mucous membranes, increase blood lipid levels, and lead to impaired liver function, depression, and suicidal tendencies. In addition, this drug has a teratogenic effect and cannot be recommended in women of childbearing age [11]. The topical application of these drugs may cause skin irritation. It is also important that their use requires adherence to a clear regimen of administration, and in real clinical practice there is often a violation of the rules of admission by the patient.

Low efficacy, side effects, and duration of treatment with antibiotics and retinoids are prerequisites for finding new, safe, and effective ways to treat acne. In this context, various safe and effective physiotherapy procedures are becoming a new trend in the treatment of acne. One of the possible alternative methods of treatment can be photodynamic therapy (PDT) [1,11].

PDT in the treatment of acne

PDT is used for various tumor and precancerous skin pathologies [12,13,14]. A number of studies have shown that PDT is safe and effective in both inflammatory and non-inflammatory acne and can significantly improve skin conditions in this disease. Moreover, since the reactive oxygen species produced by PDT do not have any specific molecular target, PDT makes it possible to easily bypass drug resistance in microorganisms, which gives this therapy an advantage over antibiotic treatment. The effectiveness of PDT against acne is mainly due to a decrease in the amount of sebum produced by the sebaceous glands due to a decrease in their activity as a result of direct photodynamic damage to the sebaceous glands, eradication of *C. acnes* and a decrease in the level of hyperkeratosis [1,15].

The first edition of the 2002 European Clinical Guidelines for Local PDT contained information on the

Таблица
Сводные данные результативности применения фотодинамической терапии у больных акне
Table
Summary of the effectiveness of photodynamic therapy of acne

Авторы Authors	Число пациентов / No. of patients	Фотосенсибилизатор Photosensitizer	Режим облучения Exposure mode	Количество курсов ФДТ Number of PDT courses	Эффективность ФДТ PDT efficiency	Нежелательные реакции Adverse reactions
Asayama-Kosaka et al., 2014 [20]	11	5% 5-АЛК, аппликация 2 ч 5% 5-ALA, application 2 h	Широкополосное облучение (600-1100 нм), 15 Дж/см^2, 60 мВт/см^2 Broadband irradiation (600-1100 nm), 15 J/cm^2, 60 mW/cm^2	Однократно Once	Средний балл GAGS снизился с 22,1±3,8 в начале исследования до 19,4 через 1 мес и до 16,3 через 3 мес после ФДТ. The mean GAGS score decreased from 22.1±3.8 at baseline to 19.4 at 1 month and to 16.3 at 3 months after PDT.	У 10 из 11 пациентов наблюдались местные побочные эффекты, такие как эритема (от минимальной до легкой степени тяжести). Все нежелательные явления прошли в течение нескольких дней без поствоспалительной гиперпигментации. Ten out of 11 patients experienced local side effects such as erythema (from minimal to mild severity). All adverse events resolved within a few days without post-inflammatory hyperpigmentation.
Chen et al., 2015 [21]	Группа ФДТ – 25 пациентов (1 группа сравнения: только облучение) PDT group – 25 patients (1 comparison group: only irradiation)	5% 5-АЛК, аппликация 1,5 ч 5% 5-ALA, application 1,5 h	633±10 нм, 120 Дж/см^2, 10 мВт/см^2 633±10 nm, 120 J/cm^2, 10 mW/cm^2	1 раз в неделю, 3 недели 1 time per week, 3 weeks	Общий показатель эффективности в группе ФДТ составил 54,2% против 21,6% в контрольной группе через 2 нед после лечения, 75,0% против 43,5% через 4 нед и 83,3% против 56,5% через 6 нед, соответственно. The overall success rate in the PDT group was 54.2% vs. 21.6% in the control group 2 weeks after treatment, 75.0% vs. 43.5% after 4 weeks, and 83.3% vs. 56.5% after 6 weeks, respectively.	В группе ФДТ 7 пациентов испытывали жжение, боль, эритему и отек в течение 1-4 дней после ФДТ. У 3 пациентов наблюдалась временная гиперпигментация. У 2 пациентов появились высыпания на коже. В контрольной группе у 2 пациентов наблюдались покраснение и сухость лица. In the PDT group, 7 patients experienced burning, pain, erythema, and edema within 1-4 days after PDT. Three patients had transient hyperpigmentation. 2 patients developed skin rashes. In the control group, redness and dryness of the face were observed in 2 patients.

Calzavara-Pinton et al., 2013 [22]	92	16% МЭ-АЛК, аппликация 3-4 ч 16% MAL, application 3-4 h	635±18 нм, 37 Дж/см^2, 10 мВт/см^2 635±18 nm, 37 J/cm^2, 10 mW/cm^2	От 2 до 4 курсов с интервалом 2-4 недели From 2 to 4 courses with an interval of 2-4 weeks	Общее улучшение течения акне было оценено как выраженное у 71 (77,2%) пациента, умеренное у 12 (13,0%) пациентов и слабое у 9 (9,8%) пациентов. У 67 (72,8%) пациентов косметический результат, был оценен как отличный. The overall improvement in the course of acne was assessed as pronounced in 71 (77.2%) patients, moderate in 12 (13.0%) patients, and weak in 9 (9.8%) patients. In 67 (72.8%) patients, the cosmetic result was rated as excellent.	У 4 пациентов с типом кожи IV на месте лечения образовались участки гиперпигментации. In 4 patients with skin type IV, areas of hyperpigmentation formed at the treatment site.
Liu et al., 2014 [3]	Группа ФДТ – 50 пациентов (2 группы сравнения: импульсное облучение и только облучение LED) PDT group – 50 patients (2 comparison groups: pulsed irradiation and LED irradiation only)	5% 5-АЛК, аппликация 1 ч 5% 5-ALA, application 1 h	633±6 нм, 127 Дж/см^2, 105 мВт/см^2 633±6 nm, 127 J/cm^2, 105 mW/cm^2	1 раз в неделю, до очищения очагов на 90% и более (в среднем количество курсов 3±1,5) 1 time per week, until the foci are cleared by 90% or more (on average, the number of courses is 3 ± 1.5)	Через 1 мес после начала лечения у 60% пациентов – полное очищение кожи, у 32% – умеренное улучшение, у 8% – небольшое улучшение. 1 month after the start of treatment, 60% of patients have complete skin cleansing, 32% have a moderate improvement, and 8% have a slight improvement.	У 46 (92%) пациентов после каждого курса ФДТ были отмечены легкая или умеренная боль, эритема и отек, которые проходили в течение 5-7 дней. У 2 (4%) пациентов наблюдалась гиперпигментация, которая прошла через 1 мес. In 46 (92%) patients after each course of PDT, mild or moderate pain, erythema and edema were noted, which disappeared within 5-7 days. In 2 (4%) patients, hyperpigmentation was observed, which disappeared after 1 month.
Tao et al., 2016 [23]	125	3,6% 5-АЛК, аппликация 1,5 ч 3,6% 5-ALA, application 1,5 h	633 нм, 126 Дж/см^2, 66 мВт/см^2 633 nm, 126 J/cm^2, 66 mW/cm^2	1 раз в 2 недели, 3 курса 1 time in 2 weeks, 3 courses	Общие показатели эффективности составили 1,6%, 24,8%, 68,8%, 89,6% и 88,8% через 2, 4, 6, 8 и 12 нед после начала лечения, соответственно. The overall success rates were 1.6%, 24.8%, 68.8%, 89.6% and 88.8% at 2, 4, 6, 8 and 12 weeks after the start of treatment, respectively.	У 40 (32%) пациентов наблюдалось обострение угревой сыпи до 2 и 3 курса лечения, которое проходило после 3 курса лечения. Побочные явления были умеренными и обратимыми. In 40 (32%) patients, an exacerbation of acne was observed before the 2nd and 3rd courses of treatment, which disappeared after the 3rd course of treatment. Side effects were moderate and reversible.

Dessinioti et al., 2016 [24]	12	4% МЭ-АЛК, аппликация 1 ч 4% MAL, application 1 h	635 нм, 37 Дж/см^2 635 nm, 37 J/cm^2	1 раз в неделю, 2 курса 1 time per week, 2 courses	Количество очагов угревой сыпи снизилось в среднем на 35% от исходного уровня на 1-й неделе после двух процедур и в среднем на 30% при 4-недельном наблюдении. The number of acne lesions decreased by an average of 35% from baseline at week 1 after two treatments and by an average of 30% at a 4-week follow-up.	Пациенты хорошо переносили ФДТ. Побочные эффекты ограничивались легкой преходящей эритемой в местах лечения и продолжались несколько часов. Отеков, пустул, образования корок или стойкой эритемы не наблюдалось. Пациенты не сообщали о болевых ощущениях. The patients tolerated PDT well. Side effects were limited to mild transient erythema at the treatment sites and lasted several hours. Edema, pustules, crusting, or persistent erythema were not observed. Patients did not report pain.
Hong et al., 2013 [25]	20 У каждого пациента 2 режима лечени я (правая и левая сторона лица) 20 Each patient has 2 treatment regimens (right and left side of the face)	16% МЭ-АЛК, аппликация 3 ч 16% MAL, application 3 h	1 режим: красный свет (длина волны не указана), 22 Дж/см^2, 34 мВт/см^2 2 режим: импульсное облучение, 530-750 нм, 2,5 мс, длительность с задержкой 10 мс, 8-10 Дж/см^2) 1 mode: red light (wavelength not specified), 22 J/cm^2, 34 mW/cm^2 2 mode: pulsed irradiation, 530-750 nm, 2.5 ms, duration with a delay of 10 ms, 8-10 J/cm^2)	1 раз в 2 недели, 3 курса 1 time in 2 weeks, 3 courses	В результате воздействия обоих режимов количество очагов угревой сыпи уменьшилось. Результаты были чуть лучше при воздействии режима 1. As a result of exposure to both regimens, the number of acne foci decreased. The results were slightly better when exposed to mode 1.	Побочные явления были умеренными и обратимыми. Side effects were moderate and reversible.
Yew et al., 2016 [26]	15	5% 5-АЛК, аппликация 3 ч 5% 5-ALA, application 3 h	630 нм, 37 Дж/см^2, 38 мВт/см^2 630 nm, 37 J/cm^2, 38 mW/cm^2	Однократно Once	В целом, к концу 12-недельного наблюдения количество воспалительных поражений сократилось на 64,2%, количество невоспалительных поражений – на 24,3%. In general, by the end of the 12-week follow-up, the number of inflammatory lesions decreased by 64.2%, the number of non-inflammatory lesions by 24.3%.	Незначительные болевые ощущения. Minor pain.
Guo et al., 2023 [11]	18	5% 5-АЛК, аппликация 1-1,5 ч 5% 5-ALA, application 1-1,5 h	630 нм, 60 Дж/см^2 630 nm, 60 J/cm^2	1 раз в неделю, 2 курса 1 time in 2 weeks, 2 courses	Показатель эффективности с 1 по 3 неделю наблюдения увеличился с 27,78% до 55,56%, а затем до 83,33%. The success rate from 1 to 3 weeks of observation increased from 27.78% to 55.56%, and then to 83.33%.	Побочные явления были умеренными и обратимыми. Side effects were moderate and reversible.

possibility of using PDT for the treatment of warts and acne, with 5-amnolevulinic acid (5-ALA) being listed as the most widely used PDT drug. The recommendations also contained an indication of the possibility of using both coherent and incoherent light sources for PDT [16]. By 2008 [17], PDT for the treatment of acne, warts, and cutaneous leishmaniasis was rated clinical recommendation level IB (strength of recommendation B, quality of evidence I). In the latest edition of the European Clinical Guidelines for Local PDT, severe acne remains indicated as an indication for PDT with an IB level [11].

Guo et al., based on almost 20 years of experience in the clinical use of PDT for the treatment of severe acne, conclude that, compared with systemic drug therapy, the treatment of severe acne with PDT has the following advantages: fast results, high efficiency, high selectivity, no systemic adverse reactions, drug resistance, and low recurrence rate [1]. Picone et al. [18] also indicate that the undoubted advantage of PDT for the treatment of acne is the absence of scars after treatment.

Interestingly, low concentrations of the photosensitizer, short incubation time, and low light doses (about 13 J/cm^2) under blue light irradiation provide short-term antimicrobial and immunomodulatory effects, while higher light doses (up to 150 J/cm^2) of red light additionally cause destruction of the sebaceous glands. An additional effect of all PDT modes, leading to a decrease in follicle obstruction and a decrease in sebum secretion, is an increase in epidermal renewal [4].

In recent years, several large clinical studies have been conducted on the efficacy and safety of PDT in the treatment of acne using 5-ALA and 5-ALA methyl ester (ME-ALA) (Table). Even though there were no reports on the use of chlorin derivatives for PDT in patients with acne in clinical practice, *in vitro* and *in vivo* studies using chlorins also showed satisfactory results [19]. Phthalocyanines, to the best of our knowledge, have not yet been investigated for the treatment of this skin pathology.

We searched for published results of studies on the clinical efficacy of PDT in acne patients over the past 10 years using the Pubmed database. We included in the analysis only studies conducted with the participation of 10 or more patients, in which PDT was performed in mono mode using standard sources and irradiation modes. Selected clinical cases of interest are further described below. The analysis made it possible to identify 9 studies that present data obtained in total in the treatment of 368 patients with acne (Table). Most studies have used 5% of 5-ALA as an application for 1-4 hours for PDT. In one study, the concentration of 5-ALA was lower – 3.6%. Three studies used ME-ALA for PDT at a standard concentration of 16% or a lower concentration of 4%. For irradiation, red light was most often used. Light doses ranged from 15 to 120 J/cm^2. All studies have shown an overall improvement in acne after PDT.

The main task in the development of the PDT method in the field of acne treatment at the moment is the search for regimens that reduce pain and the development of local reactions in the area of irradiation while maintaining the high treatment efficiency achieved in previous studies.

A number of studies demonstrate a significant reduction in the intensity of pain during an irradiation session and other adverse events while maintaining high treatment efficiency during low-intensity PDT. For example, in a study by Chen *et al.,* [21] PDT with a light dose of 120 J/cm^2 and a power density of 10 mW/cm^2 caused significant pain, burning, erythrema, and edema that persisted up to 4 days after PDT in 28% of patients and temporary pigmentation in 12% of patients. Liu *et al.* [3] reported the development of adverse events (moderate pain, erythrema, and edema lasting up to 5 days) in 92% of patients after PDT with a light dose of 127 J/cm^2 and a power density of 105 mW/cm^2. In a study by Calzavara-Pinton *et al.* [22], the light dose was reduced to 37 J/cm^2 at a power density of 10 mW/cm^2. The authors of the study did not report significant pain sensations or other adverse events. Only 4% of patients with skin type IV developed areas of hyperpigmentation at the treatment site.

Pain sensations are also reduced with the use of 5-ALA and ME-ALA at lower concentrations than usual. For example, in a study by Dessinioti *et al.* [24] ME-ALA cream was used for PDT with a concentration 4 times lower than the standard (4%). Side effects were limited to mild transient erythema at the treatment sites and lasted several hours. Edema, pustules, crusting, or persistent erythema were not observed. Patients did not report pain. At the same time, the effectiveness of treatment was quite high – immediately after 2 courses of PDT, the number of acne foci decreased by an average of 35% from the initial level.

Many researchers note that the use of high concentrations of 5-ALA for acne PDT causes significant side effects. For example, Pollock et al. [27] reported on the use of 5-ALA in 10 patients with acne at a concentration of 20% with application for 3 hours. Despite the rather sparing irradiation regimen (15 J/cm^2, 25 mW/cm^2), patients experienced significant pain during the irradiation session and erythrema. The effectiveness of the treatment was even lower than when using lower concentrations of 5-ALA: after the second course of treatment, a statistically significant decrease in the number of inflammatory foci of acne was observed in the treatment area compared to the baseline, but not in comparison with the control areas. As a result of the treatment, no statistically significant amount of *C. acnes* or the level of sebum secretion was obtained.

Some researchers recommend shortening the application time of 5-ALA as a way to reduce the intensity of

pain during irradiation. Thus, the results of one recent small-scale study in which 5% 5-ALA cream was used in patients with acne showed that a reduction in the application time from 90 to 30 minutes led to an almost complete absence of pain during irradiation in patients with the same effectiveness of treatment [28]. Chinese dermatologists also give the results of studies demonstrating that PDT with a 5-ALA concentration of 3–5% and a shorter application time (30 min) can effectively improve the condition of moderate to severe acne vulgaris with minimal pain and other adverse reactions [29].

The use of a ventilator, air cooling, and possible short breaks in irradiation may also be used to reduce treatment-related pain during PDT. Local anesthesia can usually be used before and after PDT [30].

A separate promising area of application of PDT in patients with acne is PDT after ineffective acne treatment by other methods, in particular, after an exacerbation of the disease during isotretionine treatment. Despite the fact that no large-scale studies of the effectiveness of PDT in this group of patients have been conducted, several interesting clinical cases have been described in the literature. Thus, Liu J. et al. [31] report the successful treatment of a patient with acne flare-ups after treatment with isotretionin. Acne *exacerbation* develops in a small proportion of patients at the start of oral isotretinoin. Clinically, it usually manifests as painful, ulcerated, and hemorrhagic lesions. Traditional therapy in this case is the ingestion of corticosteroids. However, in some patients, such therapy can also be accompanied by side effects, such as metabolic disorders, suppression of immune function, and other effects. The authors report a young man with acne exacerbation after taking isotretinoin, who was treated with PDT (2-hour application of 5% 5-ALA, irradiation 633±6 mm, 42 mW/cm^2, 75.6 J/cm^2, 7 cycles). The result of the treatment was rated as a complete cleansing of the skin with an excellent cosmetic result). Picone et al. [18] report another case of successful treatment of acne exacerbation while taking isotretionine. PDT was performed in a patient with ulcerative and hemorrhagic lesions from acne on the face and trunk with an exacerbation of the disease after the start of treatment with isotretinoin, which did not respond to systemic prednisolone in combination with topical application of clindamycin and disinfectants. The patient underwent 6 courses of PDT with ME-ALA (application of 16% ointment) with red light irradiation (630 nm, light dose 39 J/cm^2). At a 6-month follow-up, the patient showed no active lesions, only scarring, and no side effects were reported during and after each treatment session.

Conclusion

In recent years, the method of acne treatment, PDT, has been actively developed, demonstrating high efficiency and a satisfactory safety profile. For acne PDT, 5-ALA and ME-ALA are used. Both drugs show high efficacy in both inflammatory and non-inflammatory lesions, in mild, moderate, and severe forms of acne, as well as after ineffective acne treatment by other methods, in particular after an exacerbation of the disease during treatment with isotretionine. The main direction in the development of PDT in acne patients is the search and development of low-intensity PDT schemes to minimize pain and local reactions to radiation.

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