Effect of 5-Aminolevulinic Acid Photodynamic Therapy on Serum IL-6, IL-21, IL-23 and T_h17/T_{reg} Cell Balance in Moderate to Severe Acne

YUANYUAN LI AND LIQIAO CHI*

Department of Dermatology, Qingpu Branch of Zhongshan Hospital Affiliated to Fudan University, Qingpu, Shanghai 201700, China

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To investigate the effects of 5-aminolevulinic acid photodynamic therapy on serum interleukin-6, interleukin-21, interleukin-23 and T cells 17/regulatory T cell balance in moderate to severe acne patient. 70 patients with moderate to severe acne who visited our dermatology outpatient clinic from January 2023 to August 2023 were selected as the research object and were divided into the experiment group (n=35) and the control group (n=35); the experiment group were treated with 5-aminolevulinic acid-based photodynamic therapy, while the control group was given 1 mg/bid isotretinoin capsules. The patients of the two groups were treated for 6 w; enzyme-linked immunosorbent assay to detect the serum interleukin-6, interleukin-21 and interleukin-23 level. Flow cytometry to detect the percentage of helper T cells 17 and regulatory T cell. Statistical Package for the Social Sciences software to analyze the spearman correlation between interleukin-6, interleukin-21, and interleukin-23 level with T cells 17/regulatory T cell balance. There were no statistical difference in the comparison of general information between the experiment and control groups (p>0.05). The therapeutic effect of the experiment group was more than the control group (p<0.05). Before treatment, serum interleukin-6, interleukin-21, and interleukin-23 levels have no statistical difference (p>0.05) between the two groups. After treatment, there were no statistical difference in serum interleukin-6, interleukin-21 and interleukin-23 levels (p>0.05). Serum interleukin-6, interleukin-21 levels were positive correlation with regulatory T cell/T cells 17 balance, while interleukin-23 levels were negative correlation with regulatory T cell/T cells 17 balance. Serum interleukin-6, interleukin-21, interleukin-23 level and peripheral blood T cells 17/regulatory T cell balance were associated to the therapeutic effect of moderate and severe acne patients after treatment. 5-aminolevulinic acid-based photodynamic therapy significantly improved the therapeutic effect of moderate and severe acne, but had no effect on serum interleukin-6, interleukin-21, interleukin-23 and peripheral blood T cells 17/regulatory T cell balance.

Key words: Acne, 5-aminolevulinic acid photodynamic therapy, interleukin-6, interleukin-21, interleukin-23, T regulatory cell/T cells 17 balance

Acne is a commonly seen chronic inflammatory disease of follicular sebaceous glands, which occurs in sebaceous gland-rich areas. As a multifactorial skin disease, the incidence of acne is as high as 39.2 % among adolescents and adults in mainland China[1]. With improving living standards and changes in dietary habits, there is a growing trend in the incidence of acne[2]. Moderate to severe acne, characterized by pustules, cysts, and nodules, can lead to pigmentation and disfiguring scars, causing significant psychological distress and adversely affecting the life quality and mental well-being of patients. For moderate to severe acne, clinical management often involves the systemic use of antibiotics and retinoids[3]. However, concerns about the adverse effects of retinoic acid preparations and the impact on fertility in men and women of childbearing age, as well as the continued emergence of antibiotic resistance, have limited the use of retinoic acid preparations and antibiotics[4].

5-Aminolevulinic Acid-Photodynamic Therapy

(5-ALA-PDT) has gradually emerged as a treatment modality for moderate to severe acne and has shown certain clinical efficacy[5,6], but the mechanism of its action, especially the immunological mechanism, has not been fully elucidated. Some study suggests that the functional interplay between helper T Cells 17 (T_h17) and Regulatory T Cells (T_{reg}), with their mutual antagonism, in maintaining body immune homeostasis plays a pivotal role. Their imbalance leads the transitional activation of T_h17 cells, which is the key to the pathogenesis of acne[7]. T_h17 cells contribute to the development of acne by secreting various cytokines[8], whereas T_{reg} cells secrete a variety of anti-inflammatory cytokines to prevent excessive inflammatory response and reduce its damage to body functions[9].

Inflammatory factors in the immune response play a very crucial role. Interleukin (IL)-6 belongs to pro-inflammatory factors, which inhibits T_{reg} cell differentiation and T cell apoptosis by activating the immune system, recruiting monocytes, stimulating endothelial and smooth muscle cell expression[10]; IL-21 is mainly synthesized and secreted by Natural Killer (NK) cells and activated Cluster of Differentiation (CD) 4^+ T cells, regulates various immune responses by affecting multiple immune cells[11]; IL-23 primarily acts on T_h17 cells, in T_h17 cells proliferation and stability playing a crucial role. It can also promote the production of cytokines in T_h17 cells, participating in the progression of various diseases[12].

Given these factors, this investigate aims to assess the change of serum IL-6, IL-21, IL-23, and peripheral blood T_{reg}/T_h17 cell balance in patient with moderate to severe acne before and after 5-ALA-PDT treatment. This research aims to gain further insight into the immunological mechanisms of 5-ALA-PDT treatment for moderate to severe acne, providing an experiment basis and theoretical support for treatment of moderate to severe acne.

MATERIALS AND METHODS

Materials:

After approval by the hospital Medical Ethics Committee, 70 moderate to severe acne patients who visited the dermatology outpatient clinic at our hospital from January 2023 to August 2023 were selected as study subject. They were divided into a control group and experiment group, each consisting of 35 patients. The study workflow is depicted in fig. 1.
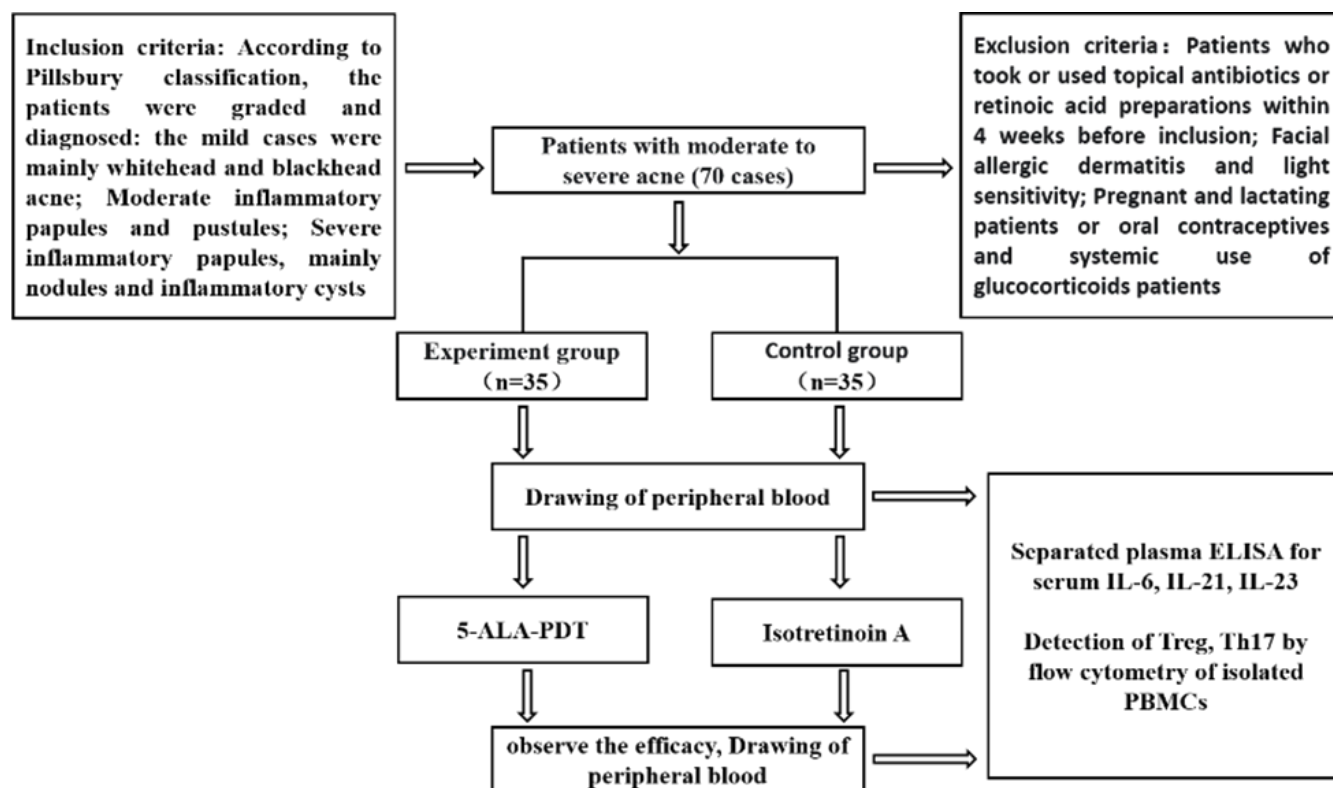

Fig. 1: Research flow chart

Inclusion and exclusion criteria:

Inclusion criteria: Refer to Pillsbury classification for grading and diagnosing the patients; in mildly, whiteheads and blackhead pimples predominate; in moderately, inflammatory papules and pustules predominate and in severely, inflammatory papules with nodules and inflammatory cysts predominate.

Exclusion criteria: Patients who took or used antibiotics and retinoic acid preparations within 4 w before enrollment; patients with facial atopic dermatitis and photosensitivity; patients who were pregnant and lactating or taking oral contraceptives and patients with systematic application of glucocorticoids. The control group should also exclude patients with hyperlipidemia, liver and kidney function abnormalities.

Treatment:

The control group was given 10 mg bid isotretinoin capsules for 6 w. The experiment group was given 5-ALA-PDT: first, the lesions were pretreated with sterile disposable needles, then fresh gel was used to make 5 % Aminolevulinic Acid (ALA) gel, which was evenly applied to the lesions, sealed with plastic wrap, and then irradiated with laser light at a wavelength of 635 nm for 60 min after avoiding the light for 30 min, with the total energy of the laser light being 126 J/cm^2, and the area not easily reached was irradiated additionally for 20 min. The total laser energy was 126 J/cm^2, and for the areas not easily reached by light, supplemental irradiation was performed for 20 min, once every 2 w, and the treatment was stopped after healing.

Evaluation of efficacy:

The assessment of lesion improvement was categorized as follows; ≥90 % reduction in lesions was classified as "cured"; 70 %-89 % reduction was classified as "excellent effective"; 30 %-69 % reduction was classified as "improved" and <30 % reduction or worsening was classified as "ineffective".

Detection of serum IL-6, IL-21 and IL-23 levels:

Before each treatment, take 3 ml of fasting venous blood from patients in the early morning by using heparin anticoagulation tube, centrifuged at 3000 rpm for 15 min, take the serum preserved at -80°. The serum was measured the level of IL-6, IL-21, and IL-23 by Enzyme-Linked Immunosorbent Assay (ELISA).

Peripheral blood T_{reg} and T_h17 cell ratio assay:

Single nucleated cells were separated from the remaining blood cells using lymphocyte isolation solution, and 1640 complete culture solution with 10 % fetal bovine serum, ionomycin (10 ng/ml), add Phorbol Myristate Acetate (PMA) (1 μM) sequentially, culture in incubator at 37°, 5 % Carbon dioxide (CO_2), protected from light for 3 h, then add Blefeldin A (10 mg/ml), continue culture for 1 h, and the incubation was terminated.

Cell staining: Complete stimulation of Peripheral Blood Mononuclear Cell (PBMC) was mixed with Fluorescein Isothiocyanate (FITC)-CD4, Peridinin Chlorophyll Protein (PerCP)-CD3 antibody, culture for 20 min at room temperature under light protection, washed twice use phosphate buffer, fixed with fixation rupture agent, ruptured the membrane and added PE-IL-10, APC-foxp3, PE-Cy5-IL-17, PE-Cy7-IL23, incubated at room temperature under light protection for 20 min and washed twice. Using flow cytometry, 10 000 cells were acquired with cell quest software for analysis, and the results were expressed as percentages.

Flow data analysis: BD Software Cell Quest can be used to analyze, first CD4 circle gate to analyze the CD4$^+$ T cell subpopulation, followed by labeling the T_{reg} cell subpopulation with CD25, foxp3, and combining with IL-10 for the detection of T_{reg} cytokine secretion function; after the CD3 and CD4 circle gates, the percentage of IL-17 and IL-23 in CD4$^+$ T cells were detected, which is the T_h17 cells.

Statistical methods:

By Statistical Package for the Social Sciences (SPSS) 26.0 statistical analysis software analyze data. For measurement data, difference between groups were compared used t-test, result was presented as x̄±s. For count data, difference between group were compared used the Chi Square (χ^2) test, result was presented as n (%); p<0.05 represents statistical significance.

RESULTS AND DISCUSSION

Age, gender, duration of disease, family history, degree of disease, cumulative site and clinical manifestations of patients were analyzed for differences in experiment group and control group. The findings showed the two group have no statistical difference (p>0.05) (Table 1), which

means that the grouping was reasonable and the results after treatment were comparable.

In order to investigate purpose, the effectiveness of 5-ALA-PDT therapy treating moderate to severe acne, firstly, we compared the experiment and control group effective rate at different time points, which showed that, in experiment group the effective rate was greater than the control group at the 2nd and 4th w (p<0.05), and no significant difference between the experiment and control group in the effectiveness at 6 w (p>0.05), no difference between the two groups in the total efficiency (p>0.05) (Table 2). To further compare the efficacy between experiment and control group at different time point, result showed that between the two groups the difference in efficacy at w 2, 4 and 6 was no significant difference, while the experiment group total effectiveness was remarkably better than the control group (p<0.05) (Table 3).

To find out effectiveness of 5-ALA-PDT therapy on IL-6, IL-21, IL-23 level, ELISA assay was performed to measure the level of them in whole blood supernatant. The results revealed no difference between the experiment and the control group before treatment in serum IL-6, IL-21 and IL-23 levels (p>0.05); After treatment, there was no difference in the same efficacy between the experiment and control group in the serum IL-6, IL-21, IL-23 level (p>0.05); after treatment, in cured, excellent effective and improved groups the levels of serum IL-6, IL-21 were lower than before treatment (p<0.05), while compared with before treatment the level of IL-23 were higher (p<0.05); in ineffective group the serum IL-6, IL-21 ,IL-23 level were not different from those before treatment (p>0.05) and there were differences in serum IL-6, IL-21 and IL-23 level between the same group after treatment with different curative effects group (p<0.05). The IL-6, IL-21 levels gradually decreased with the improvement of curative effect, while the levels of IL-23 gradually increased with the improvement of curative effect (Table 4-Table 6).

TABLE 1: COMPARISON OF GENERAL INFORMATION OF PATIENTS IN THE EXPERIMENT GROUP AND CONTROL GROUP

Indicator	Experiment group (n=35)	Control group (n=35)	t/χ^2	p
Gender			0.058	0.81
Male	15 (42.9)	16 (45.7)		
Female	20 (57.1)	19 (54.3)		
Age	22.06±2.485	21.11±3.488	-1.303	0.198
Duration of disease (months)	18.23±2.129	17.63±2.276	-1.139	0.259
Family history			0.108	0.743
No	29 (82.9)	30 (85.7)		
Yes	6 (17.1)	5 (14.3)		
Degree of disease			0.062	0.803
Moderate	13 (37.1)	12 (34.3)		
Severe	22 (62.9)	23 (65.7)		
Cumulative area			0.791	0.852
Cheeks	11 (31.4)	14 (40)		
Nose	12 (34.3)	12 (34.3)		
Frontal	8 (22.9)	6 (17.1)		
Perioral	4 (11.4)	3 (8.6)		
Clinical manifestations			0.265	0.876
Pustules	12 (34.3)	10 (28.6)		
Cysts	11 (31.4)	12 (34.3)		
Nodules	12 (34.3)	13 (37.1)		

TABLE 2: COMPARISON OF EFFECTIVE RATE BETWEEN EXPERIMENT GROUP AND CONTROL GROUP

Time	Group	Number of people	Effective	Ineffective	Effective rate	χ^2	p
2 w	Experiment	35	15	20	42.86	4.242	0.039
	Control	35	7	28	20.00		
4 w	Experiment	34	25	9	73.53	5.534	0.019
	Control	35	16	19	45.71		
6 w	Experiment	31	29	2	93.55	0.451	0.502
	Control	34	29	5	85.29		
Total	Experiment	35	33	2	94.43	0.635	0.426
	Control	35	30	5	85.71		

TABLE 3: COMPARISON OF EFFICACY BETWEEN EXPERIMENT GROUP AND CONTROL GROUP

Time	Group	Number of people	Cured	Excellent effective	Improved	Ineffective	χ^2	p
2 w	Experiment	35	1	5	9	20	5.213	0.157
	Control	35	0	2	5	28		
4 w	Experiment	34	3	9	13	9	6.235	0.101
	Control	35	1	5	10	19		
6 w	Experiment	31	5	15	9	2	6.027	0.110
	Control	34	2	10	17	5		
Total	Experiment	35	9	15	9	2	7.976	0.047
	Control	35	3	10	17	5		

TABLE 4: COMPARISON OF SERUM IL-6 (ng/l) LEVELS BETWEEN EXPERIMENT GROUP AND CONTROL GROUP

	Efficacy	Experiment group	Control group
Before treatment	~	110.505±26.681[bcd]	105.599±26.307[bcd]
After treatment	Cured	22.875±4.271[acde]	23.765±3.002[acde]
	Excellent effective	46.264±11.259[abde]	45.017±14.291[abde]
	Improved	79.347±12.4[abce]	83.971±18.522[abce]
	Ineffective	105.55±5.67[bcd]	102.472±5.348[bcd]

Note: [a]p<0.05, comparison of pre-treatment with the same group; [b]p<0.05, comparison of cure with the same group; [c]p<0.05, comparison of apparent effect with the same group; [d]p<0.05, comparison of improvement with the same group and [e]p<0.05, comparison of ineffectiveness with the same group

TABLE 5: COMPARISON OF SERUM IL-21 (ng/l) LEVELS BETWEEN EXPERIMENT GROUP AND CONTROL GROUP

	Efficacy	Experiment group	Control group
Before treatment	~	259.031±28.545[bcd]	263.926±22.688[bcd]
After treatment	Cured	38.614±4.144[acde]	38.946±3.603[acde]
	Excellent effective	126.171±12.793[abde]	132.911±8.706[abde]
	Improved	201.432±23.184[abce]	197.653±20.003[abce]
	Ineffective	257.865±19.169[bcd]	255.320±11.501[bcd]

Note: [a]p<0.05, comparison of pre-treatment with the same group; [b]p<0.05, comparison of cure with the same group; [c]p<0.05, comparison of apparent effect with the same group; [d]p<0.05, comparison of improvement with the same group and [e]p<0.05, comparison of ineffectiveness with the same group

TABLE 6: COMPARISON OF SERUM IL-23 (ng/l) LEVELS BETWEEN EXPERIMENT GROUP AND CONTROL GROUP

	Efficacy	Experiment group	Control group
Before treatment	~	278.919±21.589[bcd]	273.032±14.142[bcd]
After treatment	Cured	552.726±18.871[acde]	530.077±14.274[acde]
	Excellent effective	488.753±10.338[abde]	484.588±11.097[abde]
	Improved	389.338±10.174[abce]	390.243±6.289[abce]
	Ineffective	272.100±5.445[bcd]	269.848±3.532[bcd]

Note: [a]$p<0.05$, comparison of pre-treatment with the same group; [b]$p<0.05$, comparison of cure with the same group; [c]$p<0.05$, comparison of apparent effect with the same group; [d]$p<0.05$, comparison of improvement with the same group and [e]$p<0.05$, comparison of ineffectiveness with the same group

For investigate the effectiveness of 5-ALA-PDT therapy on T_{reg}/T_h17 balance, the T_{reg}, T_h17 percentages of in blood cells were detected used flow cytometry, T_{reg}/T_h17 values were calculated. The result showed that before treatment, hasn't difference in T_{reg}, T_h17 and T_{reg}/T_h17 between the experiment group and the control group ($p>0.05$); after treatment, the experiment group and the control group had the same efficacy there was no difference in T_{reg}, T_h17, T_{reg}/T_h17 ($p>0.05$); After treatment, T_h17 was higher than before treatment in the cured, excellent effective and improved group ($p<0.05$), compared with before treatment, the Treg, T_{reg}/T_h17 was lower ($p<0.05$), compared with the before treatment, there was no difference between T_{reg}, T_h17, T_{reg}/T_h17 in the ineffective group ($p>0.05$); there was a significant difference in T_{reg}, T_h17, T_{reg}/T_h17 among different efficacy group after treatment among the same group ($p<0.05$), and T_{reg} and T_{reg}/T_h17 gradually decreased, while T_h17 gradually increased with the improvement of the efficacy (Table 7-Table 9).

In order to investigate whether there is a correlation between IL-6, IL-21, IL-23 levels and T_{reg}/T_h17 cell balance, spearman correlation analysis was done by SPSS statistical analysis software analysis. The result showed that serum IL-6, IL-21 level were positive correlated with T_{reg}/T_h17 cell homeostasis in both experiment groups and control groups, while IL-23 levels were negative correlated with T_{reg}/T_h17 cell homeostasis (fig. 2).

Photodynamic Therapy (PDT) is used to treat various types of location-related cancers and non-tumor diseases by applying a photosensitizer externally and then irradiating locally with a specific wavelength of light, after absorbing light, photosensitizers react with oxygen in a series of ways, and play a therapeutic role through cytotoxic effects or intentional cell biological behaviors[13]. 5-amino-ketovalerate has become a commonly used photosensitizer due to its advantages of easy synthesis, easy local use and easy absorption[14]. More and more studies have shown that 5-ALA-PDT can treat various skin diseases, such as refractory condyloma acuminatum[15], diabetic foot ulcer infection[16], and psoriasis[17]. Moderate and severe acne is also a kind of skin disease with multiple and severe skin lesions and easy to leave pigmentation and scars. This research revealed that the experiment group therapeutic efficacy was significantly more favorable than the control group, which indicated that ALA-PDT was effectively treat moderate to severe acne, which was in line with Zhang et al.[18] findings.

Some studies had shown that 5 % ALA-PDT therapies in treatment of acne are clinically effective, which is conducive to the improvement of skin lesion symptom in patients, and at the same time, it can significantly reduce patient's serum IL-1β, IL-6, and CRP levels[19]. It has also been shown that 5-ALA-PDT has good efficacy in patients with high-risk Human Papilloma Virus (HPV) infection with condyloma acuminatum, which can increase serum IL-17, IL-23 level, reduce IL-10 level[20]. However, in this study, it was found that, there were no difference in the IL-6, IL-21, IL-23 level in the same efficacy group between the experiment and control group after treatment, there were difference in IL-6, IL-21, IL-23 level between same group with different efficacies after treatment, which indicated that the 5-ALA-PDT treatment did not affect the inflammatory factor levels, the inflammatory factor level were related to the efficacy of treatment, which was

in contradiction to the findings of other scholars as mentioned above. Results of the study, which contradicts the results of other scholars mentioned above. Since 5-ALA-PDT therapy can improve the efficacy, there are differences in the inflammatory factor level in different efficacies group, and the inflammatory factor level were not grouped by efficacy to be compared after treatment in their study, which may be the reason for the contradictory results.

T_h17 cell are a new identified subpopulation of T cell that secrete IL-17[21]; in the immune system T_{reg} cells are fundamental cells and belong to a class of $CD4^+$ T cell subpopulations with low proliferative capacity[22]. T_h17 cells, T_{reg} cells are derived from the same precursor cells, they require tumor growth factor-Beta (β) signaling to initial differentiation[23]. Eventually differentiation cells perform contrary functions: T_h17 cells induce inflammation and autoimmunity, while T_{reg} cells suppress these processes, maintain immune homeostasis[23]. With the increasing research on these two types of cells, relevant studies have reported that abnormalities in T_{reg}/T_h17 cell balance in the development of inflammatory diseases play a crucial role[21,24]. The finding of this study indicated that the T_{reg}/T_h17 ratio in cured,

efficacious, improved groups after treatment was smaller than before treatment, as well as the T_{reg}/T_h17 ratio after treatment gradually reduced with the improvement of the efficacy of the treatment, suggesting the T_{reg}/Th_{17} cells imbalance is involved in the moderate to severe acne development, which is in line with the findings of other scholars mentioned in the previous section. After treatment, there was no difference in the T_{reg}/T_h17 ratio in the same efficacy between two group, suggesting that 5-ALA-PDT therapy did not affect the T_{reg}/T_h17 cell balance.

In conclusion, serum IL-6, IL-21, IL-23 level and peripheral blood T_{reg}/T_h17 cell balance were associated with post-treatment efficacy in moderate to severe acne patient. 5-ALA-PDT therapy significantly improved the therapeutic effect of moderate and severe acne, but has no effect on patient's serum IL-6, IL-21, IL-23 level and peripheral blood T_{reg}/T_h17 cell balance. Because of the limited numbers of cases collected in this research, the sensitivity of individual patients to external drugs is different, and the influence of multiple factors such as lesion site, quantity, drug concentration and treatment time, it is necessary to conduct a high quality, multicenter, large sample randomized double-blind controlled experiment for verification.

TABLE 7: COMPARISON OF T_{reg} PERCENT CHANGES BETWEEN EXPERIMENT GROUP AND CONTROL GROUP

	Efficacy	Experiment group	Control group
Before treatment	~	4.391±0.765[bcd]	4.353±0.806[bcd]
After treatment	Cured	2.041±0.152[acde]	2.017±0.204[acde]
	Excellent effective	2.852±0.251[abde]	2.852±0.364[abde]
	Improved	3.682±0.288[abce]	3.640±0.384[abce]
	Ineffective	4.445±0.403[bcd]	4.454±0.282[bcd]

Note: [a]p<0.05, comparison of pre-treatment with the same group; [b]p<0.05, comparison of cure with the same group; [c]p<0.05, comparison of apparent effect with the same group; [d]p<0.05, comparison of improvement with the same group and [e]p<0.05, comparison of ineffectiveness with the same group

TABLE 8: COMPARISON OF T_h17 PERCENT CHANGES BETWEEN EXPERIMENT GROUP AND CONTROL GROUP

	Efficacy	Experiment group	Control group
Before treatment	~	1.071±0.136[bcd]	1.088±0.183[bcd]
After treatment	Cured	1.460±0.0332[acde]	1.453±0.050[acde]
	Excellent effective	1.329±0.061[abce]	1.329±0.060[abce]
	Improved	1.211±0.057[abce]	1.202±0.032[abce]
	Ineffective	1.090±0.0848[bcd]	1.080±0.0436[bcd]

Note: [a]p<0.05, comparison of pre-treatment with the same group; [b]p<0.05, comparison of cure with the same group; [c]p<0.05, comparison of apparent effect with the same group; [d]p<0.05, comparison of improvement with the same group and [e]p<0.05, comparison of ineffectiveness with the same group

TABLE 9: COMPARISON OF CHANGES IN T_{reg}/T_h17 CELL BALANCE BETWEEN EXPERIMENT GROUP AND CONTROL GROUP

	Efficacy	Experiment group	Control group
Before treatment	~	4.246±1.252[bcd]	4.242±1.558[bcd]
After treatment	Cured	1.399±0.117[acde]	1.391±0.187[acde]
	Excellent effective	2.150±0.207[abce]	2.155±0.331[abce]
	Improved	3.044±0.248[abce]	3.029±0.335[abce]
	Ineffective	4.105±0.689[bcd]	4.122±0.145[bcd]

Note: [a]p<0.05, comparison of pre-treatment with the same group; [b]p<0.05, comparison of cure with the same group; [c]p<0.05, comparison of apparent effect with the same group; [d]p<0.05, comparison of improvement with the same group and [e]p<0.05, comparison of ineffectiveness with the same group
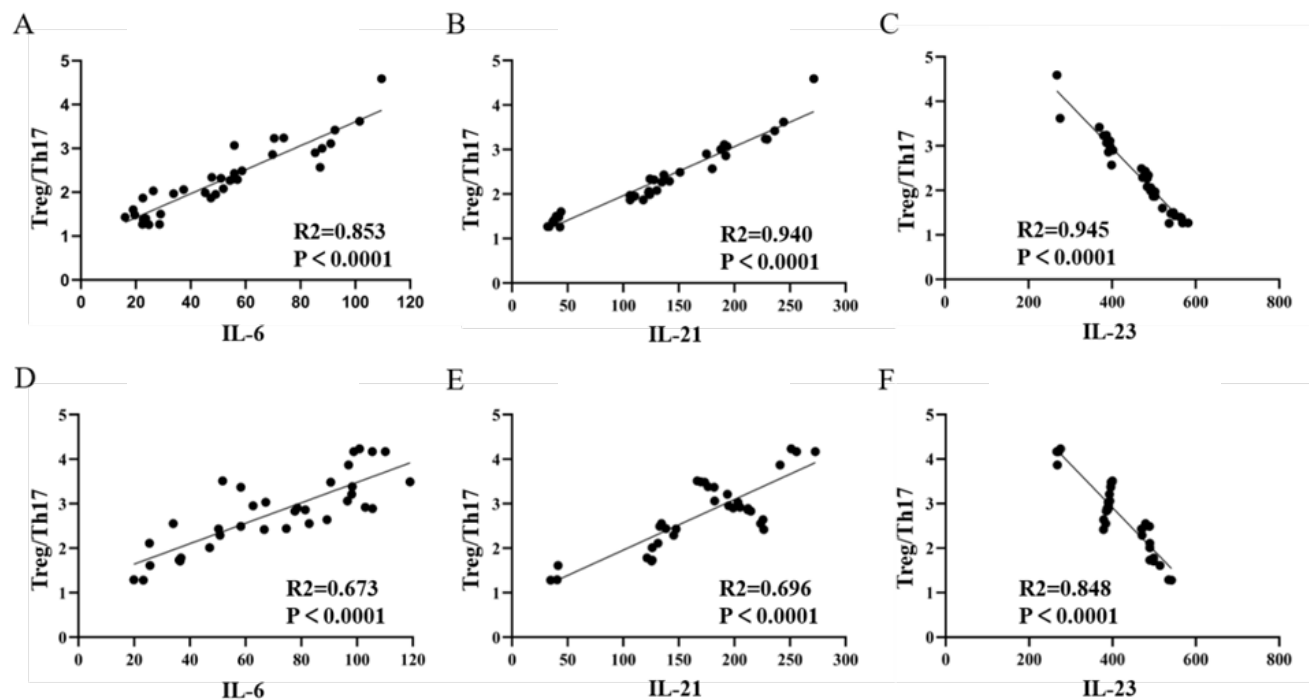
Fig. 2: Correlation between IL-6, IL-21, IL-23 levels and T_{reg}/T_h17 cell homeostasis in different efficacy groups after treatment in the experiment group and control group, (A): Correlation analysis between IL-6 levels and T_{reg}/T_h17 cell homeostasis in the experimental group; (B): Correlation analysis between IL-21 levels and T_{reg}/T_h17 cell homeostasis in the experimental group; (C): Correlation analysis between IL-23 levels and T_{reg}/T_h17 cell homeostasis; (D): Correlation analysis of IL-6 levels and T_{reg}/T_h17 cell homeostasis in the control group; (E): Correlation analysis of IL-21 levels and T_{reg}/T_h17 cell homeostasis in the control group and (F): Correlation analysis of IL-23 levels and T_{reg}/T_h17 cell homeostasis in the control group

In addition, the combination of ALA-PDT treatment with acne medications may greatly improve the treatment outcome, after permitting further research. Serum IL-6, IL-21, IL-23 level and peripheral blood T_{reg}/T_h17 cell balance were associated with post-treatment efficacy in moderate to severe acne patient. 5-ALA-PDT therapy significantly improved the therapeutic effect of moderate and severe acne, but has no effect on patient's serum IL-6, IL-21, IL-23 level and peripheral blood T_{reg}/T_h17 cell balance.

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Conflict of interests:

The authors declared no conflict of interests.

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