

# *Clinical application of silk fibroin composite gel in wound repair after laser treatment of freckles*

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**Keywords:** Silk fibroin hydrogel; Q-switched Nd:YAG laser; Facial ephelides; Post-inflammatory hyperpigmentation; Cutaneous restitution; Biomimetic polymers

**Abstract:** To observe the clinical efficacy of silk fibroin composite gel in preventing post-inflammatory hyperpigmentation (PIH) and promoting wound healing following 532-nm Q-switched Nd:YAG laser treatment for facial freckles. A total of 123 patients were randomly divided into a composite gel group ( $n=41$ , Siruimei Biotechnology), a patch group ( $n=41$ , Fangchenggang Ruiyi Biotechnology), and a control group ( $n=41$ , ice compress and mupirocin ointment). The results showed that the scab formation time ( $2.08 \pm 0.61$  days) and scab shedding time ( $4.12 \pm 0.77$  days) in the composite gel group were significantly shorter than those in the patch group and the control group ( $P<0.001$ ). At 1 month after treatment, the PIH incidence rate in the composite gel group was 36.59%, which was significantly lower than 63.41% in the control group ( $P<0.05$ ). In conclusion, the application of silk fibroin composite gel after laser surgery can effectively speed up skin healing and reduce PIH. It is better than traditional dressings and has high clinical application value.

## 1. Introduction

Freckles are a very common skin disease in the clinic. They are usually brown spots on the face. They bring a great influence to the facial beauty and psychological health of the patients. At present, the 532-nm Q-switched Nd: YAG laser is widely used to treat freckles. It can destroy melanin cells effectively [1]. However, the high laser energy damages the normal skin barrier. It brings a serious acute local inflammatory response. After the surgery, the wound healing process is very important. If the healing time is too long, the inflammation will stimulate the skin to produce more melanin. Finally, it causes post-inflammatory hyperpigmentation (PIH). This PIH problem is very common in Asian people [2].

Traditional post-operative care usually uses ice compress and mupirocin ointment. Ice compress can lower the skin temperature. Mupirocin can prevent bacterial infection. But they are only basic physical and chemical methods. They cannot actively help cell growth or rebuild the extracellular matrix (ECM). So, more and more researchers pay attention to new biological materials. Silk fibroin is a kind of natural protein extracted from silkworm cocoons. It has excellent biocompatibility and no immunogenicity [3]. Its structure is very close to human skin proteins. Recent studies show that silk fibroin can act as a bioactive dressing. It can promote fibroblast movement, keep the wound moist, and speed up skin healing [4].

Based on the above, our study compares silk fibroin composite gel, silk fibroin patch, and traditional care. We aim to observe the clinical effect of silk fibroin composite gel for wound healing and PIH prevention after laser treatment.

## 2. Materials and Methods

### 2.1 General Information

We selected 123 patients with facial freckles who received laser treatment in our hospital. We randomly divided them into a composite gel group ( $n=41$ ), a patch group ( $n=41$ ), and a control group ( $n=41$ ). The age and disease severity of the three groups had no statistically significant differences ( $P>0.05$ ). The three groups were comparable.

#### 2.1.1 Inclusion criteria

- (1) Diagnosis of facial freckles;
- (2) No laser or chemical peeling treatments in the past 6 months;
- (3) Patients signed the informed consent form.

#### 2.1.2 Exclusion criteria

- (1) Local skin infection on the face;
- (2) History of keloids or scar constitution;
- (3) Pregnant or lactating women.

### 2.2 Treatment Methods

All patients received 532-nm Q-switched Nd: YAG laser treatment. After the laser surgery, the patients received different care:

- (1) Composite Gel Group: Applied silk fibroin composite gel (Siruimei Biotechnology (Zhejiang) Co., Ltd.; Registration No.: 20242141765) immediately. Then patients used it twice a day for 14 continuous days.
- (2) Patch Group: Applied silk fibroin medical patch (Fangchenggang Ruiyi Biotechnology Co., Ltd.; Registration No.: 20252140091) immediately for 30 minutes. Then patients used it once a day for the first 7 days, and every other day for the next 7 days.
- (3) Control Group: Used traditional ice compress immediately for 30 minutes. Then patients used mupirocin ointment twice a day for 14 continuous days.

### 2.3 Observation Indicators

- (1) Wound Healing Time: Recorded the scab formation time and scab shedding time (days).
- (2) PIH Incidence: At 1 month after treatment, recorded the number of patients who got PIH.

### 2.4 Statistical Analysis

SPSS 26.0 software was used for statistical analysis. Measurement data were expressed as mean  $\pm$  standard deviation ( $\bar{x} \pm s$ ) and analyzed by one-way ANOVA. Count data were expressed as percentages (%) and analyzed by the chi-square ( $\chi^2$ ) test.  $P < 0.05$  meant the difference was statistically significant.

### 3. Results

#### 3.1 Comparison of Wound Healing Times

The scab formation time and scab shedding time were shortest in the composite gel group, followed by the patch group, and longest in the control group. The differences among the three groups were statistically significant ( $P < 0.001$ ). (See Table 1.)

Table 1. Comparison of Wound Healing Times among the Three Groups ( $\bar{x} \pm s$ , days)

Group	<i>n</i>	Scab Formation Time	Scab Shedding Time
Composite Gel	41	2.08 ± 0.61	4.12 ± 0.77
Silk Fibroin Patch	41	2.15 ± 0.68	4.33 ± 0.98
Control	41	3.25 ± 0.71	7.14 ± 1.22
<i>F</i> value	—	39.578	114.980
<i>P</i> value	—	< 0.001	< 0.001

#### 3.2 Comparison of Hyperpigmentation Incidence

At 1 month after treatment, the PIH incidence rate in the composite gel group was 36.59%. The patch group was 48.78%. The control group was 63.41%. The PIH rate in the composite gel group was significantly lower than that in the control group ( $P < 0.05$ ). (See Table 2.)

Table 2. Comparison of PIH Incidence at 1 Month Post-Treatment [*n* (%)]

Group	<i>n</i>	Hyperpigmentation Cases	Incidence Rate (%)
Composite Gel	41	15	36.59
Silk Fibroin Patch	41	17	41.46
Control	41	26	63.41
$\chi^2$ value	—	—	6.72
<i>P</i> value	—	—	< 0.05

### 4. Discussion

Wound healing after laser surgery is a very complex process. Q-switched laser can break melanin into pieces. But the high energy also destroys the stratum corneum and causes tissue damage. This brings an acute inflammatory response. Inflammatory factors can stimulate melanocytes to produce more melanin. If the inflammation lasts for a long time, it will cause PIH [5]. Traditional post-operative care usually uses ice compress and ointment. Ice compress can only relieve pain for a short time. It cannot actively provide a biological scaffold to help cell growth or reduce skin water loss.

Silk fibroin is a kind of bioactive dressing. Its amino acid structure is very similar to human collagen. It can act as a biological shield. It guides keratinocytes to move and protects nerve endings from external damage [6]. In our study, the scab formation time (2.08 ± 0.61 days) and scab shedding time (4.12 ± 0.77 days) in the composite gel group were significantly shorter. This shows that silk fibroin has good effects on wound repair.

At the same time, compared with the silk fibroin patch, the composite gel showed better results. This is because the gel is semi-solid. Human faces have complex curves. The patch cannot cover the skin completely. But the gel can stick to the face seamlessly. It can keep the wound moist continuously and give amino acids to the deep skin [7].

Because the wound healing is fast, the inflammation time is short. This can effectively prevent

melanin production. In our study, the PIH rate in the composite gel group was only 36.59%. This is significantly lower than the control group (63.41%). Although the patch group also had some clinical benefits, the gel is better because it is used every day and fits the skin better.

In conclusion, the application of silk fibroin composite gel after Q-switched laser treatment for facial freckles is better than traditional care. It can effectively speed up wound healing and reduce PIH. It is a safe and effective biological material, and it has high clinical application value.

## References

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