



Intense Pulsed Light Therapy Improves Acne-Induced Post-inflammatory Erythema and Hyperpigmentation: A Retrospective Study in Chinese Patients

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ABSTRACT

Introduction: Post-inflammatory erythema (PIE) and post-inflammatory hyperpigmentation (PIH) are the most common acne-related sequelae with no effective treatments. By combining different cut-off filters, intense pulsed light (IPL) therapy can effectively treat these conditions with few side effects. While the safety and effectiveness of IPL for treating post-burn hyperpigmentation is well known, there is

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little evidence for its benefits for acne-related PIH. In this article, we evaluate the efficacy and safety of IPL for the treatment of acne-related PIE and PIH.

Methods: This retrospective study evaluated 60 patients with more than 6 months of PIE and PIH treated by the same IPL device and similar protocols. The treatment included three to seven sessions at 4–6-week intervals, and three cut-off filters (640 nm, 590 nm and 560 nm) were used sequentially in each session. Using the Global Aesthetic Improvement Scale (GAIS), Cardiff Acne Disability Index (CADI), and Erythema Assessment Scale (EAS), patients were evaluated on the basis of their facial photographs. The facial brown spots and red areas were visualised and analysed using the VISIA-CR system. Six months after the last treatment, the patients were assessed for acne relapse or any side effects.

Results: On the basis of the GAIS, 49 of 60 patients (81.7%) showed complete or partial clearance of erythema and hyperpigmentation. The CADI and EAS scores showed significant improvement ($p < 0.01$) after IPL treatment compared with pre-treatment. A significant reduction ($p < 0.01$) in the facial brown spots and red areas was seen after IPL treatment. While no long-term side effects were reported, seven patients (11.7%) experienced acne relapse at follow-up.

Conclusion: IPL is an effective and safe treatment for acne-related PIE and PIH.

Keywords: Intense pulsed light; Acne; Post-inflammatory erythema; Post-inflammatory hyperpigmentation

Key Summary Points

Since post-inflammatory erythema (PIE) and post-inflammatory hyperpigmentation (PIH) are the most common acne-related sequelae with no effective treatments, treatment using energy-based devices is increasingly preferred by physicians and patients because of their effective performance, short downtime, and fewer adverse effects.

By combining different cut-off filters, we found significant improvement in PIE and PIH using intense pulsed light (IPL) therapy.

IPL could be an effective and safe therapeutic option for acne-related PIE and PIH, with few side effects.

INTRODUCTION

Acne vulgaris is one of the most common types of acne, with an incidence as high as 85% in adolescent men and women. However, 12% of women and 3% of men remain affected until middle age [1]. Owing to time-consuming and cost-intensive treatments, patients suffer from significantly reduced quality of life and serious psychological problems [2, 3]. Adolescent patients, especially, often suffer from stigma, anxiety, depression, withdrawal, discrimination and other psychological distress due to facial acne. The impact of acne, which exceeds that of asthma and epilepsy, makes it difficult for adolescents to integrate into a group [4].

The skin lesions of acne vulgaris tend to occur on the face. Owing to chronic inflammation, the patients experience pain, itching and various sequelae. The most common acne-related sequelae are post-inflammatory

erythema (PIE) and post-inflammatory hyperpigmentation (PIH), which often present together. PIE consists of telangiectasia and erythematous papules, usually present after the clearance of inflammatory acne. These vascular lesions are mainly located very close to the skin surface and have a red appearance due to the concentration of minor blood vessels in that area [5]. Although facial PIE very slowly improves with time, in some cases, it is never completely cleared [6]. Acne-related PIH presents as localised or diffuse brown-to-grey-brown macules at sites of acne lesions and becomes most apparent after PIE has resolved. An Asian Acne Board study found PIH in 58.2% of patients with acne. Besides, PIH persists for at least 1 year in more than 50% of these patients and 5 years or longer in 22.3% of patients [7]. However, to date, no criteria are available for predicting the outcome of PIH/PIE, which is cosmetically unacceptable for patients and leads to psychological distress. Conventional treatments, such as chemical peeling and isotretinoin, are effective in treating PIE and PIH, but the long treatment period and adverse reactions are often difficult to tolerate.

Intense pulsed light (IPL) has been widely used to treat a variety of skin pigmentation and vascular diseases. IPL devices are broadband-filtered xenon flashlamps based on selective photothermolysis. Most IPL devices emit 400–1200 nm wavelengths targeting porphyrin, melanin, haemoglobin and water. Recent studies have reported the successful application of IPL for acne treatment [8–10].

Despite these available treatment options, an effective and safe procedure for managing acne that resolves its vascular sequelae and reduces pigmentary disorders is still needed. To the best of our knowledge, this is the first and largest study that evaluates the long-term effects of IPL treatment on acne-induced PIE and PIH.

METHODS

Study Design

Patients treated using IPL in our department between January 2020 and December 2021 were

screened for the following criteria: diagnosed with acne-induced PIE and PIH for more than 6 months without self-relieving trends, no combined therapy, a unified treatment protocol (use of the same IPL devices, cut-off filters and treatment intervals), and at least 6 months of follow-up. This study was approved by the Ethical Committee of Shanghai Ninth People's Hospital, and informed consent was obtained from each patient prior to the initiation of IPL treatment. The procedures followed were in accordance with the Helsinki Declaration of 1975, as revised in 1983. Finally, 60 patients were included in this retrospective analysis.

Treatment

The wavelength spectrum of the IPL device (BBL, Sciton, Inc, Palo Alto, CA) used in this study ranged from 400 to 1200 nm. Three cut-off filters were sequentially used in each session: 640 nm (8–12 J/cm², 30–35 ms), 590 nm (8–12 J/cm², 15–20 ms) and 560 nm (6–10 J/cm², 12–15 ms), cooling to 12–15 °C, one pass, with 10–20% overlap. The treatments involved three to seven sessions at 4–6-week intervals depending on the severity of acne in each patient. No topical anaesthesia was required prior to IPL irradiation. A 5–8-mm-thin layer of coupling gel was applied to the entire face. Following the procedure, patients were advised to use an ice bag for 15 min. Sunscreen is recommended 2 weeks before the procedure and thereafter.

Evaluations

Photographs were taken with a digital camera (60D camera; Canon, Tokyo, Japan) and VISIA-CR (Canfield Scientific, Fairfield, NJ) before each session and 6 months after the final session. The patients filled out a questionnaire on-site or remotely, including the 5-point Global Aesthetic Improvement Scale (GAIS) [11] and Cardiff Acne Disability Index (CADI) [12]. Two independent dermatologists evaluated the Erythema Assessment Scale (EAS) [13] on the basis of the patients' photographs. The persistence or clearing of lesions was evaluated on the basis of

visual examination using standardised photography and quantitative analysis using the VISIA digital imaging system. Post-treatment responses including erythema, oedema and other side effects were recorded for each patient.

Data Analysis

The data obtained were analysed using SPSS 20.0 (IBM, Armonk, NY, USA) and GraphPad Prism 7 (GraphPad Software, San Diego, CA, USA). The non-normal data (CADI, EAS and brown spots) were evaluated using Wilcoxon signed-rank test. Differences in the normally distributed data (red areas) were compared using paired *t*-test. A *p* value < 0.05 was considered statistically significant.

RESULTS

Demographic Characteristics of Participants

A total of 60 patients (52 women and 8 men) were included in this retrospective analysis. The mean age of the participants was 29 (range 22–37) years. While 38 patients (63.3%) had a Fitzpatrick skin type (FST) III, 22 (36.7%) had an FST IV. Thirty-five patients (58.3%) had PIE and PIH for > 6 months but < 12 months, while 25 (41.7%) had them for > 12 months. While 1 patient (2%) received 7 sessions of treatment, 2 (4%), 34 (56.7%), 11 (18.3%) and 12 patients (20%) received 6, 3, 4, and 5 sessions, respectively.

GAIS, CADI and EAS

Two participants demonstrated 'exceptional improvement', and one, shown in Fig. 1a, had almost total clearing of PIE and PIH along with an overall rejuvenated appearance (tone, glossiness and laxity). Further, 21 participants (35%, Fig. 1b) were assessed as 'very improved', while 26 (43.3%, Fig. 1c) had 'improved' and 11 (18.3%) remained 'unaltered'. In short, 49 of 60 patients (81.7%) showed complete or partial clearance of erythema and hyperpigmentation.



◀**Fig. 1** Improvement of facial PIE and PIH. Photographs before (a, c) and after (b, d) IPL treatment show improvement in facial PIE and PIH. In addition, visual examination shows clearance of PIE and PIH, reduced acne lesions, and improvement in skin texture and tone. 1A, GAIS = 1, exceptional improvement; 1B, GAIS = 2, marked improvement; 1C, GAIS = 3; improvement. *IPL* intense pulsed light, *PIE* post-inflammatory erythema, *PIH* post-inflammatory hyperpigmentation, *GAIS* Global Aesthetic Improvement Scale

In accordance with the GAIS trends, compared with the baseline, the CADI at follow-up (6 months after the last session) showed significant improvement (Fig. 2a). The overall mean CADI score before IPL treatment was 9 (IQR 7–10), suggesting moderate quality of life (QOL) impairment. However, at the end of follow-up, the mean CADI score was 7 (6–8), suggestive of mild QOL impairment and significant improvement ($p < 0.01$). The EAS was also significantly reduced after the IPL treatments (Fig. 2b, $p < 0.01$).

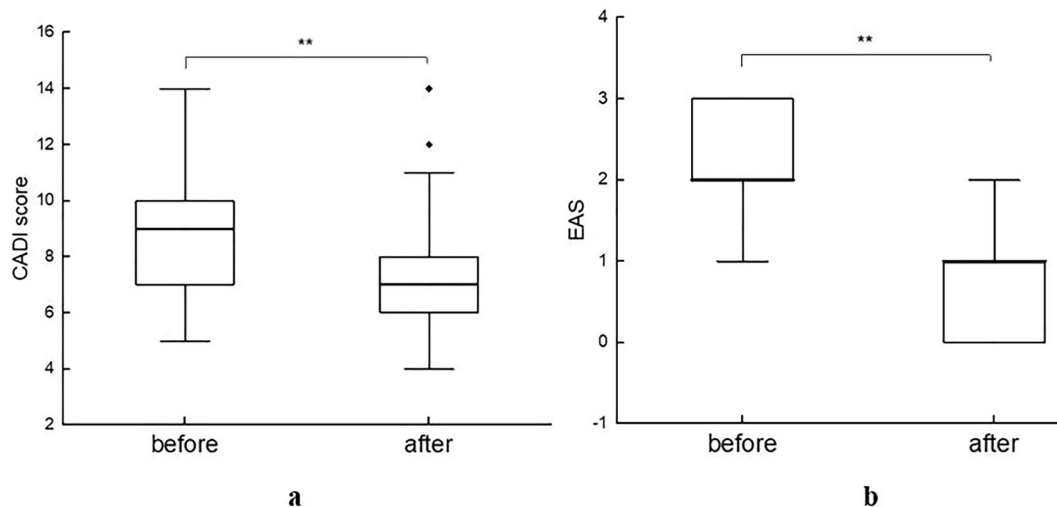


Fig. 2 Changes in CADI and EAS scores following IPL treatment. The CADI (a) and EAS (b) scores before and after IPL treatment are shown. Since these scores did not conform to a normal distribution, the data are shown

VISIA-CR Images

The facial photographs of 17 patients were recorded with the VISIA-CR digital imaging system at baseline and the end of follow-up. The red facial areas and brown spots were quantitatively analysed (Fig. 3). These two features showed significant improvement after IPL treatment (Fig. 4a, b, $p < 0.01$).

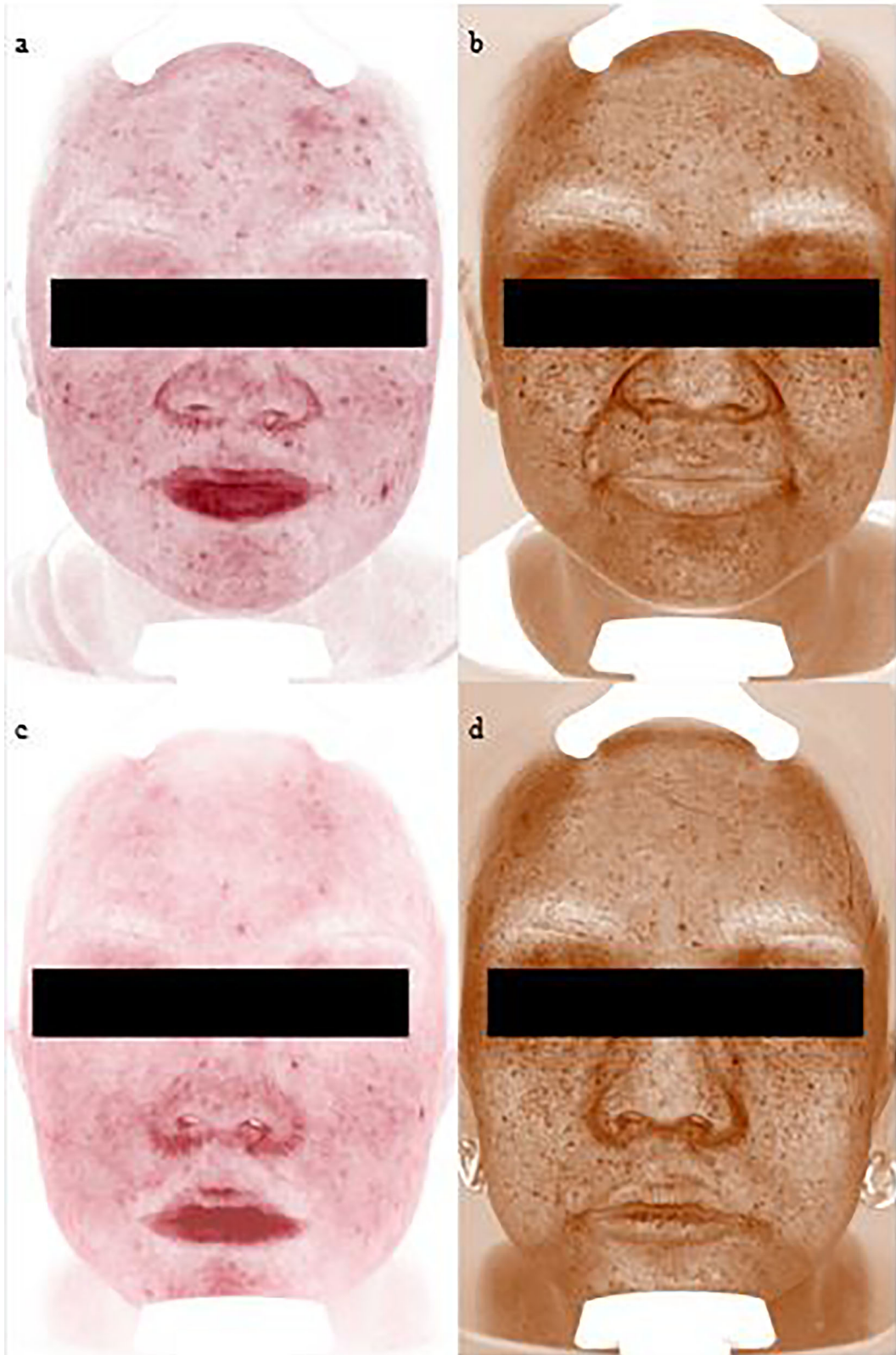
Relapse and Side Effects

All patients tolerated IPL treatment-related pain well without topical anaesthetic agents. Adverse events were limited to transient erythema, dryness and itching at treatment sites, which resolved within 48 h in most patients. Acne relapsed in seven patients (11.7%) at the end of follow-up.

DISCUSSION

In general, the GAIS and CADI values showed that IPL treatment significantly improved the overall facial appearance and the quality of life of patients with acne. The combined use of

using median (IQR) and were compared using the Wilcoxon signed-rank test. $**p < 0.01$. *IPL* intense pulsed light, *CADI* Cardiff Acne Disability Index, *EAS* Erythema Assessment Scale



◀**Fig. 3** Representative VISIA-CR images. Shown are the red areas and brown spots before (a, b) and after (c, d) treatment

different cut-off filters targeted not only melanin and haemoglobin but also ‘rejuvenated’ the skin (restored skin elasticity, reduced wrinkles and shrank pores) by promoting collagen growth through photothermal and biochemical effects [14, 15]. The change in CADI values indicated an improved quality of life and positive impact of IPL treatment.

Since PIE is resistant to topical and oral drugs [16], energy-based devices are increasingly preferred by physicians and patients because of their effective performance, short downtime and fewer adverse effects. The 595 nm pulsed dye laser (PDL) is generally the first-line modality for treating superficial vascular skin lesions, such as telangiectasia, rosacea and port-wine stains. In a pilot study, Ho et al. reported clinical improvement of PIE, decreased lesion counts and enhanced skin elasticity following treatment with 595 nm PDL (fluence 9.5–11 J/cm², pulse width 10 ms, spot size 7 mm, two

sessions every 4 weeks) [5]. However, another split-face study that used almost similar parameters (fluence 8 J/cm², pulse width 10 ms, spot size 7 mm, two sessions every 2 weeks) could not reproduce the positive clinical outcomes [17].

Fractional microneedling radiofrequency has also been evaluated for the treatment of PIE [18] given its anti-inflammatory effects and ability to cause dermal remodelling [5, 19]. Clinical improvement and consistent histological changes were attributed to controlled inflammation and modulated neovasculogenesis. Consistent with a previous report [20], we found decreased EAS and red areas recorded by the VISIA-CR system. IPL-induced vascular destruction is mainly caused by selective photothermolysis. As the targeted chromophores, the major absorption peaks of oxy-/deoxy-haemoglobin are 418 nm, 542 nm and 577 nm/555 nm. Thus, 560 nm and 590 nm are the most frequently used cut-off filters to deliver the wavelength around the absorption of haemoglobin to cause coagulation and thrombosis of dermal vessels.

PIH is more common than PIE in the darker FSTs (III–VI) owing to the activation/

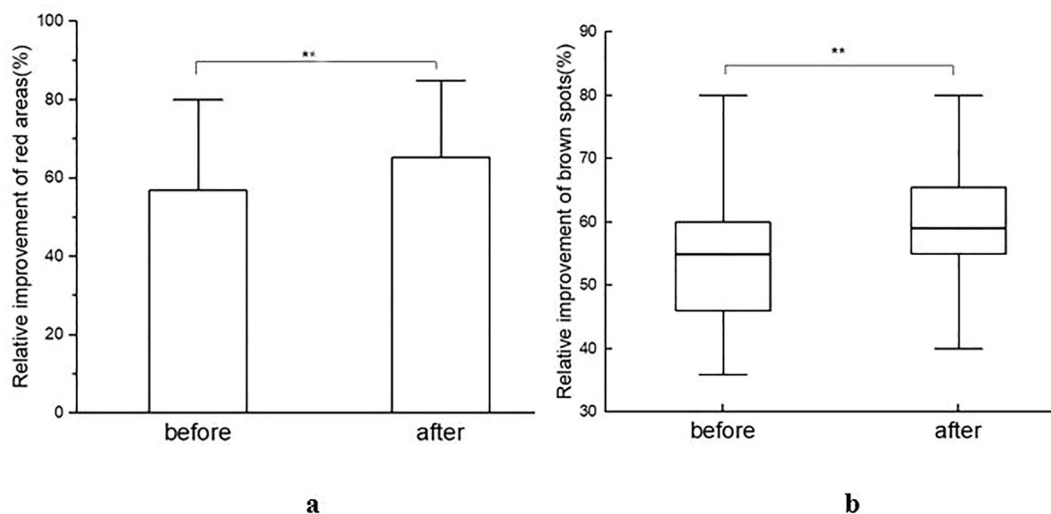


Fig. 4 Improvement in PIE and PIH after IPL treatment. Statistical analysis shows an improvement in the red areas (a) and brown spots (b). The brown spots did not conform to a normal distribution and were compared

using Wilcoxon signed-rank test. The red areas conformed to a normal distribution and were compared using paired *t*-test. ***p* < 0.01

proliferation of melanocytes in response to stimulation by prostaglandins, leukotrienes and other inflammatory molecules [21, 22]. Acne-related overproduction of melanin and abnormal pigment deposition generally occurs in the epidermal tissue and may improve with time [23]. However, in several patients, acne-related PIH is characterised mainly by increased melanin deposition or melanophages in the dermis, which tends to persist for several years and may be permanent in some cases [24]. The reported energy-based devices (non-ablative fractional lasers and microneedling) treat PIH by increasing epidermal regeneration and decreasing pigmented cells [25, 26]. Notably, in darker FSTs, inappropriate treatment with these devices tends to cause or exacerbate PIH owing to irritation. While several studies have shown IPL to be an effective and safe modality for improving post-burn hyperpigmentation [27, 28], there is little evidence for its effects on acne-related PIH. The 560 nm cut-off filters are generally used for treating pigment disorders in Asian patients with significant improvement and low risk of PIH [29, 30]. Using digital photography and VISIA-CR system to count and analyse dark spots, we found significant improvement in acne-related pigment sequelae with IPL treatments. While the exact mechanism remains unclear, regulation of inflammation and cytotoxic effects on *Propionibacterium* acnes through selective photothermolysis have been proposed as potential underlying mechanisms [31, 32].

As mentioned previously, only those patients who presented with PIH and PIE for more than 6 months were recruited in our study. Before treatment, their lesions did not present self-relieving trends. Among the participants, only 6% received more than five IPL sessions. No serious IPL treatment-related side effects were reported. In our study, only 11.7% of patients experienced a relapse of acne at the end of the 6-month follow-up. Compared with the 5.6% relapse rate in participants who received oral isotretinoin therapy (period ranging from 1 to 12 months) [33], this long-term relapse prevention with IPL is acceptable because of the reduced downtime and very few side effects. Considering the above evidence, we suggest that IPL therapy should be considered as

a strategy backed by sufficient scientific justification and risk–benefit analysis.

The major limitation of our study is its retrospective nature. Since PIH and PIE in a number of patients with acne could improve with time, comparison with a control group may increase the validity and reliability of the results. Further investigations involving a split-face design are needed to confirm the therapeutic efficacy of IPL.

CONCLUSION

For the first time, we reported the safety and effectiveness of IPL as a therapeutic option for both acne-related PIE and PIH. Furthermore, IPL prevents acne relapse for a longer period compared with other treatments.

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Author Contributions. Xianglei WU, Xue WANG, Xiujuan WU and Xiaoxi LIN designed the study, performed the research, analysed data, and wrote the paper. Qingqing CEN, Wenjing XI, Ying SHANG, Zhen ZHANG contributed to refining the ideas, carrying out additional analyses and finalizing this paper.

Disclosures. Xianglei WU, Xue WANG, Xiujuan WU, Qingqing CEN, Wenjing XI, Ying SHANG, Zhen ZHANG and Xiaoxi LIN have nothing to disclose.

Compliance with Ethics Guidelines. All patients provided written, informed consent. All procedures were approved by Shanghai Ninth People's Hospital Ethics Committee. Procedures operated in this research were

completed in keeping with the standards set out in the Announcement of Helsinki and laboratory guidelines of research in China.

Data Availability. The analysed data sets generated during the study are available from the corresponding author on reasonable request.

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