

ORIGINAL ARTICLE

Clinical research on the prevention and treatment of facial scarring

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ABSTRACT

Objective: To investigate new approaches to the prevention and treatment of facial scarring by using fractional CO₂ laser therapy, platelet-rich plasma (PRP), and a combination of fractional CO₂ laser therapy and PRP to treat sutured facial wounds.

Methods: 152 patients with facial trauma admitted to the outpatient department of the Plastic Surgery Department at a Grade A tertiary hospital between March 2020 and March 2022 were selected. Using a random number table, the patients were divided into the laser treatment group ($n = 50$), the PRP treatment group ($n = 51$), and the combination treatment group ($n = 51$). All groups received the routine debridement and cosmetic suturing. One week after suture removal, the laser treatment group underwent the laser treatment; the PRP treatment group received PRP microneedling, and the combination treatment group received a combination of fractional CO₂ laser therapy and PRP treatment. The efficacy, the level of inflammatory factors, the difference in thickness between the wound site and the normal skin, and the Vancouver Scar Scale (VSS) score were compared among the three groups at baseline, 3 months, 6 months, and 1 year after treatment.

Results: Regarding the efficacy, after 6 months of treatment, the overall response rates for the laser treatment group, the PRP treatment group, and the combination therapy group were 76%, 78.43%, and 94.12%, respectively. The overall response rate in the combination treatment group was higher than that in the laser treatment group and the PRP treatment group; $\chi^2 = 6.923$, $p = .031$, $p < .05$, indicating statistical significance. After 6 months of treatment, levels of TNF- α , IL-2, and IL-6 were decreased to varying degrees in the laser treatment group, the PRP treatment group, and the combination treatment group. The levels of inflammatory factors in the combination treatment group were lower than those in the PRP treatment group and the laser treatment group ($p < .05$), indicating a statistical significance; similarly, the levels of inflammatory factors in the PRP treatment group were lower than those in the laser treatment group ($p < .05$), indicating a statistical significance. Compared with pre-treatment measurements, the thickness of scars relative to normal skin was gradually decreased in the laser treatment group, the PRP treatment group, and the combination treatment group at 3 months, 6 months, and 1 year post-treatment. The difference in thickness between the wound site and normal skin in the combination treatment group was consistently smaller than that in the PRP treatment group and the laser treatment group ($p < .05$), indicating a statistical significance; The difference in thickness between the wound site and normal skin in the PRP treatment group was consistently smaller than that in the laser treatment group ($p < .05$), indicating a statistical significance. Compared with pre-treatment levels, VSS scores were decreased in the laser treatment group, the PRP treatment group, and the combination treatment group at 3 months, 6 months, and 1 year post-treatment. The VSS scores in the combination treatment group were lower than those in the PRP treatment group and the laser treatment group ($p < .05$), indicating statistical significance; similarly, the VSS scores in the PRP treatment group were lower than those in the laser treatment group ($p < .05$), indicating statistical significance.

Conclusions: The combination of fractional CO₂ laser therapy and PRP therapy demonstrates a significant efficacy in preventing and treating facial scars. It reduces inflammation and markedly improves scar color, thickness, and texture, yielding better results than laser therapy or PRP therapy alone.

Key Words: Facial wounds, Scars, Fractional CO₂ laser, Platelet-rich plasma, Inflammatory factors

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1. INTRODUCTION

Scarring following facial wound suturing is a condition in which the lesion protrudes above the epidermis due to dysfunction and excessive proliferation of fibroblasts at the wound site, as well as excessive deposition and disorganized arrangement of the extracellular matrix.^[1] The mechanism underlying its development is complex and may be related to factors such as the patient's age, immune system status, endocrine disorders, skin tension, foreign bodies, and infection.^[2] Scarring can not only affect the appearance but also lead to functional impairments, causing significant psychological distress for patients.^[3] There are many clinical treatment methods for scars, such as surgical excision, medical treatments, compression therapy, and laser therapy, each with its own advantages and disadvantages.^[4] For patients undergoing suturing for facial wounds, early intervention is even more critical for the prevention of scarring. Fractional CO₂ laser therapy delivers high-penetration laser energy to the affected area, utilizing photothermal and bio-stimulative effects to modulate the expression of cytokines such as heat shock proteins and transforming growth factor- β . This promotes the apoptosis in dermal fibroblasts and induces collagen remodeling, thereby repairing skin damage. It is used for the clinical prevention and treatment of scars.^[5] PRP plays a mediating role in wound healing and hemostasis and is currently widely used in the treatment of acne, scars, hair loss, stretch marks, and chronic ulcers.^[6] However, there are relatively few studies on the application of fractional CO₂ laser therapy combined with PRP therapy for the scarring prevention. This study is primarily designated to investigate the efficacy of fractional CO₂ laser therapy combined with

PRP therapy in the treatment of scars resulting from facial wound suturing, with the aim of providing guidance for the clinical prevention and treatment of scarring. The results are reported as below.

2. DATA AND METHODS

2.1 General data

152 patients with facial wounds admitted to a Tertiary A hospital between March 2020 and March 2022 were selected. Using a random number table, they were divided into the laser treatment group ($n = 50$), the PRP treatment group ($n = 51$), and the combination treatment group ($n = 51$) (see Table 1).

A comparison of the general data among the laser treatment group, the PRP treatment group, and the combination treatment group showed no statistically significant differences ($p > .05$); thus, the inter-group data are comparable. This study has been approved by the Medical Ethics Committee of our hospital.

2.2 Inclusion and exclusion criteria

Inclusion criteria: Patients meeting the diagnostic criteria for facial trauma and showing indications for suturing procedures;^[7] patients who were informed of this study and signed an informed consent form.

Exclusion criteria: Patients with coagulation disorders; hepatic or renal insufficiency; recent receipt of other treatments or undergoing treatments that may affect the results of this study; severe wound infection; tendency to develop keloids.

Table 1. Demographic characteristics of patients in the laser treatment group, the PRP treatment group, and combination treatment group

		Laser Treatment Group ($n = 50$)	PRP Treatment Group ($n = 51$)	Combination Treatment Group ($n = 51$)
Gender (n)	Male	26	28	26
	Female	24	23	25
Age	Range	20-53	19-53	20-51
	Mean	35.18 $\pm$ 6.97	35.69 $\pm$ 7.81	35.41 $\pm$ 7.59
Eating	Like spicy food	28	31	29
Habits (n)	Dislike spicy food	22	20	22
Wound Sites (n)	Frontal	24	25	23
	Buccal	19	18	21
	Mandible	7	8	7
Wound Type (n)	Incision	22	23	21
	Contusion and laceration	28	28	30

2.3 Methods

2.3.1 Laser treatment group

The wound was debrided and sutured with cosmetic sutures as usual; fractional CO₂ laser therapy was performed one week after the sutures were removed. The procedure has been described as follows: the suture site was cleaned and disinfected, then Compound Lidocaine Ointment (Beijing Ziguang Pharmaceutical Co., Ltd., H20063466) was applied evenly. After 1 hour, the affected area was treated by using the SuperPulse CO₂ Fractional Laser (Lumenis, USA) in DEEP mode at an energy level of 10–15 mJ/cm² and a density of 5%, scanning the area for 2 minutes. After treatment, an ice pack was applied and the area was covered with a sterile dressing for 1–3 days. A total of 3 treatment sessions were administered, with a 3-month interval between each session.

2.3.2 PRP treatment group

The wound was debrided and closed with cosmetic sutures as usual; PRP treatment was administered one week after the sutures were removed. PRP Preparation: an appropriate amount of venous blood was drawn from the patient (typically 10–20 mL), centrifuged at 3,000 r/min for 10–15 minutes, the middle-to-upper layer of platelet-rich plasma (PRP) was collected, and then centrifuged again at 2,000 r/min for 10 minutes; the bottom layer was collected. The suture site was cleaned and disinfected, then a microneedle was used to inject PRP on both sides of the scar. The area was gently massaged to promote PRP absorption. The treatment was administered once every 28 days, with three sessions constituting one course of treatment. The treatment was continued for 2 to 3 courses.

2.3.3 Combination treatment group

The wound was debrided and closed with cosmetic sutures as usual. One week after the sutures were removed, patients received the combined fractional CO₂ laser and PRP therapy. The fractional CO₂ laser therapy was administered in the same manner as in the Laser treatment group, and the PRP treatment was administered in the same manner as in the PRP treatment group.

2.4 Observation indicators

The following relevant indicators were evaluated in the three groups of patients at the following time points: before treatment (1 week after wound sutures were removed), 3 months after treatment (prior to the laser treatment), 6 months after treatment (prior to the laser treatment), and 1 year after treatment.

2.4.1 Efficacy

The efficacy will be assessed in 6 months after treatment. (1) Scar regression: The scar was virtually invisible at the

wound site, and the color of the affected area matched that of the surrounding skin; (2) Markedly effective: More than 80 of the wound surface was smooth, and the color was close to that of the surrounding skin; (3) Effective: More than 50 of the wound surface was smooth, and the discoloration in the affected area has been improved; (4) Ineffective: The skin at the wound site was uneven and had an irregular color, contrasting sharply with the surrounding skin. Overall effectiveness rate = (Number of cases with scar regression + markedly effectiveness + effectiveness) / Total number of cases × 100%.

2.4.2 Difference in thickness between the wound site and normal skin

By using a Doppler ultrasound scanner, the thickness of the healed wound sites and the surrounding normal skin in both groups were measured before treatment and at 3 months, 6 months, and 1 year after treatment, and the difference in thickness between the wound and normal skin was calculated.

2.4.3 VSS Score

The scar status in both groups were assessed by using the VSS^[8] before treatment and at 3 months, 6 months, and 1 year after treatment. The VSS can be used to evaluate four aspects of scars: color, thickness, texture, and vascular distribution. The maximum score is 15; a higher score indicates a more severe scar.

2.4.4 Inflammatory factors

Six milliliters of morning fasting venous blood were collected from patients before treatment and at 6 months after treatment. TNF- α , IL-2, and IL-6 levels were measured by using an enzyme-linked immunosorbent assay (ELISA) kit (Shanghai Enzyme-linked Biotechnology Co., Ltd.).

2.5 Statistical analysis

SPSS 24.0 software was used for data analysis. Enumeration data were expressed as (n [%]), and the χ^2 test was adopted for comparison. Measurement data conforming to normal distribution were presented as mean $\pm$ standard deviation ($\bar{x} \pm s$). Repeated measures analysis of variance was applied for comparison among multiple groups, and the LSD- t test was used for inter-group comparisons. p value less than .05 was considered statistically significant.

3. RESULTS

3.1 Comparison of efficacy among the laser treatment group, the PRP treatment group, and the combination treatment group

At 6 months after treatment, the comparison of the overall response rates among the laser treatment group, the PRP treat-

ment group, and the combination treatment group showed a statistically significant difference ($p < .05$). The overall response rate in the combination treatment group was higher than that in the PRP treatment group and the laser treatment group, with a statistically significant difference ($p < .05$). In contrast, the comparison of overall response rates between the PRP treatment group and the laser treatment group showed no statistically significant difference ($p > .05$) (see Table 2).

3.2 Comparison of levels of inflammatory factors in the laser treatment group, the PRP treatment group, and the combination treatment group

Before treatment, there were no statistically significant differences in the levels of inflammatory factors among the laser treatment group, the PRP treatment group, and the combination treatment group ($p > .05$). At six months after treatment, the levels of TNF- α , IL-2, and IL-6 were decreased to varying degrees in the laser treatment group, the PRP treatment group, and the combination treatment group; the levels in the combination treatment group were lower than those in the PRP treatment group and the laser treatment group ($p < .05$), indicating statistically significant difference; the levels in the PRP treatment group were lower than those in the laser treatment group ($p < .05$), indicating a statistically significant

difference (see Tables 3-5).

3.3 Comparison of the difference in thickness between the wound site and normal skin in the laser treatment group, the PRP treatment group, and the combination treatment group

Before treatment, there was no statistically significant difference ($p > .05$) in the difference in thickness between the wound site and normal skin in the laser treatment group, the PRP treatment group, and the combination treatment group; the difference was not statistically significant; in comparison with the pre-treatment measurements, the differences in thickness between the wound site and normal skin in the laser treatment group, the PRP treatment group, and the combination treatment group were all decreased at 3 months, 6 months, and 1 year after treatment. Furthermore, the difference in thickness between the wound site and normal skin in the combination treatment group was significantly smaller than that in the PRP treatment group and the laser treatment group ($p < .05$), indicating a statistically significant difference; The difference in thickness between the wound site and normal skin in the PRP treatment group was significantly smaller than that in the laser treatment group ($p < .05$), indicating a statistically significant difference (see Table 6).

Table 2. Comparison of efficacy among the laser treatment group, the PRP treatment group, and the combination treatment group (n [%])

	Laser Treatment Group (n = 50)	PRP Treatment Group (n = 51)	Combination Treatment Group (n = 51)	χ^2 value	p value
Scar Regression	9 (18.00)	12 (23.53)	19 (37.25)		
Markedly Effectiveness	16 (32.00)	14 (27.45)	17 (33.33)		
Effectiveness	13 (26.00)	14 (27.45)	12 (23.53)		
Ineffectiveness	12 (24.00)	11 (21.57)	3 (5.88)		
Overall Effectiveness	38 (76.00)	40 (78.43)	48 (94.12) ^{#▲}	6.923	.031

Note. [#] indicates a comparison with the laser treatment group, $p < .05$; [▲] indicates a comparison with the PRP treatment group, $p < .05$.

Table 3. Comparison of TNF- α levels before and after treatment in the laser treatment group, the PRP treatment group, and the combination treatment group ($\bar{x} \pm s$, ng/mL)

	Laser Treatment Group (n = 50)	PRP Treatment Group (n = 51)	Combination Treatment Group (n = 51)	F value	p value
Before treatment	241.66 $\pm$ 30.71	246.32 $\pm$ 32.75	238.61 $\pm$ 34.14	1.164	.247
6 months after treatment	125.67 $\pm$ 18.52 [*]	114.35 $\pm$ 19.52 ^{*#}	79.33 $\pm$ 15.48 ^{*#▲}	53.479	< .001

Note. ^{*} indicates a comparison with pre-treatment levels within the same group, $p < .05$; [#] indicates a comparison with the laser treatment group, $p < .05$; [▲] indicates a comparison with the PRP treatment group, $p < .05$.

3.4 Comparison of VSS scores among the laser treatment group, the PRP treatment group, and the combination treatment group

Before treatment, there was no statistically significant difference in VSS scores among the laser treatment group, the

PRP treatment group, and the combination treatment group ($p > .05$). Compared with the pre-treatment levels, VSS scores were decreased in the laser treatment group, the PRP treatment group, and the combination treatment group at 3 months, 6 months, and 1 year after treatment. Furthermore,

the VSS scores in the combination treatment group were lower than those in the PRP treatment group and the laser treatment group ($p < .05$), indicating a statistically significant difference; The VSS scores in the PRP treatment group were lower than those in the laser treatment group ($p < .05$), indicating a statistically significant difference (see Table 7).

Table 4. Comparison of IL-2 levels before and after treatment in the laser treatment group, the PRP treatment group, and the combination treatment group ($\bar{x} \pm s$, ng/mL)

	Laser Treatment Group (n = 50)	PRP Treatment Group (n = 51)	Combination Treatment Group (n = 51)	F value	p value
Before treatment	44.98 $\pm$ 8.63	45.33 $\pm$ 9.21	45.19 $\pm$ 9.42	0.019	.981
6 months after treatment	32.48 $\pm$ 7.01*	29.22 $\pm$ 6.75* [#]	25.74 $\pm$ 6.15* [#] ▲	12.999	< .001

Note. * indicates a comparison with pre-treatment levels within the same group, $p < .05$; [#] indicates a comparison with the laser treatment group, $p < .05$; ▲ indicates a comparison with the PRP treatment group, $p < .05$.

Table 5. Comparison of IL-6 levels before and after treatment in the laser treatment group, the PRP treatment group, and the combination treatment group ($\bar{x} \pm s$, ng/mL)

	Laser Treatment Group (n = 50)	PRP Treatment Group (n = 51)	Combination Treatment Group (n = 51)	F value	p value
Before treatment	153.74 $\pm$ 30.42	156.29 $\pm$ 29.11	151.43 $\pm$ 28.67	0.349	.706
6 months after treatment	95.84 $\pm$ 12.30*	90.15 $\pm$ 13.72* [#]	66.73 $\pm$ 12.58* [#] ▲	72.714	.000

Note. * indicates a comparison with pre-treatment levels within the same group, $p < .05$; [#] indicates a comparison with the laser treatment group, $p < .05$; ▲ indicates a comparison with the PRP treatment group, $p < .05$.

Table 6. Comparison of the difference in thickness between the wound site and normal skin in the laser treatment group, the PRP treatment group, and the combination treatment group ($\bar{x} \pm s$, mm)

	Laser Treatment Group (n = 50)	PRP Treatment Group (n = 51)	Combination Treatment Group (n = 51)	F value	p value
Before treatment	0.63 $\pm$ 0.13	0.64 $\pm$ 0.13	0.62 $\pm$ 0.13	0.302	.740
3 months after treatment	0.54 $\pm$ 0.13*	0.49 $\pm$ 0.12* [#]	0.37 $\pm$ 0.10* [#] ▲	28.125	< .001
6 months after treatment	0.40 $\pm$ 0.10*	0.36 $\pm$ 0.08* [#]	0.24 $\pm$ 0.05* [#] ▲	55.993	< .001
1 year after treatment	0.33 $\pm$ 0.05*	0.24 $\pm$ 0.04* [#]	0.18 $\pm$ 0.04* [#] ▲	151.626	< .001

Note. * indicates a comparison with pre-treatment levels within the same group, $p < .05$; [#] indicates a comparison with the laser treatment group, $p < .05$; ▲ indicates a comparison with the PRP treatment group, $p < .05$.

Table 7. Comparison of VSS scores before and after treatment in the laser treatment group, the PRP treatment group, and the combination treatment group ($\bar{x} \pm s$, points)

	Laser Treatment Group (n = 50)	PRP Treatment Group (n = 51)	Combination Treatment Group (n = 51)	F value	p value
Before treatment	7.88 $\pm$ 1.65	7.96 $\pm$ 1.69	7.82 $\pm$ 1.71	0.089	.915
3 months after treatment	5.43 $\pm$ 1.65*	4.76 $\pm$ 1.89* [#]	2.82 $\pm$ 1.11* [#] ▲	37.132	< .001
6 months after treatment	4.32 $\pm$ 1.52*	3.41 $\pm$ 1.47* [#]	2.25 $\pm$ 0.94* [#] ▲	30.538	< .001
1 year after treatment	3.10 $\pm$ 1.22*	2.38 $\pm$ 1.19* [#]	1.76 $\pm$ 0.81* [#] ▲	19.158	< .001

Note. * indicates a comparison with pre-treatment levels within the same group, $p < .05$; [#] indicates a comparison with the laser treatment group, $p < .05$; ▲ indicates a comparison with the PRP treatment group, $p < .05$.

4. DISCUSSION

Facial injuries such as trauma, surgery, infections, and burns can all lead to scar formation as they are healing.^[9] During the scar formation process, traumatic injury causes a massive local accumulation of neutrophils and monocytes, while in-

flammatory factors gather at the wound site and persist for several weeks, leading to a traumatic inflammatory response, cell proliferation, and tissue repair, ultimately resulting in scar formation at the wound site.^[10] Scarring not only affects patients' appearance but also often causes facial itching and

pain, causing ongoing distress in their daily lives.^[11] Studies have shown that fractional CO₂ laser can alter the concentrations of various cytokines and growth factors in the affected skin. By regulating the secretion of heat shock proteins and transforming growth factor- β , among other mechanisms, they help prevent scar formation during the wound healing process.^[12] PRP is rich in α -granules and dense granules. α -granules contain large amounts of cell growth factors, such as transforming growth factor- β and its family members, as well as platelet-derived growth factors. Dense granules contain various bioactive components, including serotonin, histamine, and adenosine, and can also help regulate cell membrane permeability and alleviate local inflammation.^[13]

The results of this study show that, at 6 months after treatment, the overall response rate in the combination treatment group was higher than that in the PRP treatment group and the laser treatment group, suggesting that fractional CO₂ laser combined with PRP is significantly more effective than either treatment alone in preventing and treating scarring after facial trauma suturing. This is because fractional CO₂ laser therapy is an ablative treatment; during the procedure, the laser is directed at the affected area, creating neatly arranged, regularly shaped three-dimensional columnar zones of thermal damage within the skin tissue, which induces the accelerated repair of the surrounding skin. The mechanism of PRP therapy for scarring is primarily based on the various growth factors released by platelets, which promote tissue repair and regeneration. The combination of these two approaches can further enhance the treatment efficacy. During the scar formation process, the elevated levels of local inflammatory cytokines (such as TNF- α , IL-2, and IL-6) play a significant role.^[14] TNF- α can promote the synthesis of type I and type III collagens, which facilitate the proliferation of skin fibroblasts and lead to hypertrophic scarring. High levels of inflammation can also impede wound healing and induce the formation of hypertrophic scars. The results of this study show that at 6 months after treatment, the levels of TNF- α , IL-2, and IL-6 are decreased to varying degrees in all three groups. The levels in the combination treatment group are lower than those in the PRP treatment group and the laser treatment group, while the levels in the PRP treatment group are lower than those in the laser treatment group. This suggests that fractional CO₂ laser therapy combined with PRP is more effective in reducing inflammation at the affected site.

In addition, the results of this study show that the differences in thickness between the wound site and normal skin gradually are decreased in all three groups at 3 months, 6 months, and 1 year after treatment. The combination treat-

ment group has a significantly lower score than that in the PRP treatment group and the laser treatment group, while the PRP treatment group has a significantly smaller difference in thickness between the wound site and normal skin than that in the laser treatment group. This indicates that fractional CO₂ laser therapy combined with PRP can effectively reduce skin thickness at the wound healing site. This is because the fractional CO₂ laser, leveraging its strong penetrating ability, creates microthermal injury zones within the wound, thereby inhibiting fibrous tissue proliferation, inducing apoptosis in mid-to-deep-layer fibroblasts, altering the ultrastructure of tissue cells in the dermo-epidermal junction of the affected area, and stimulating the regeneration and remodeling of multiple layers of skin tissues. Meanwhile, the growth factors in PRP can regulate collagen synthesis and degradation, promoting the proper alignment of normal collagen fibers, which helps remodel the collagen structure within scar tissues, reduces abnormal collagen deposition, and improves the thickness and hardness of the scar.

The VSS scores from this study also show that, at 3 months, 6 months, and 1 year after treatment, all VSS subscores in the three groups are decreased to varying degrees. The VSS scores in the combination treatment group are lower than those in the PRP treatment group and the laser treatment group ($p < .05$), indicating that the combination therapy with fractional CO₂ laser and PRP is more effective than monotherapy in improving the color, texture, and thickness of the wound site after facial trauma suturing. Abnormal proliferation of capillaries in the affected area increases the local supply of blood and nutrients, promoting rapid scar proliferation; this is one of the key factors contributing to the formation of hypertrophic scars. The analysis of the causes reveals that during the wound healing process, the abnormal expression of Type I and Type III collagens, irregular collagen deposition, and the transformation of collagen from parallel fiber bundles into interwoven, dense fiber clusters, alter the texture of the skin at the wound site; The thermal and biological effects of the fractional CO₂ laser can reduce local vascular density, lower the proportion of Type I and Type III collagen expression, and promote the deposition of regularly arranged collagens. At the same time, it induces the production of immature elastin, thereby improving the texture and appearance of the skin at the wound site; The growth factors in PRP promote fibroblast proliferation and neovascularization, accelerating tissue regeneration and repair, and bringing scar tissue closer to the thickness and texture of normal skin. The combination of these two treatments for facial scars yields better improvements in skin texture and appearance.^[15, 16]

5. CONCLUSIONS

The application of fractional CO₂ laser therapy in combination with PRP to treat patients with facial injury who have undergone suturing demonstrates significant efficacy in preventing and treating scarring and is worthy of clinical recommendation.

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AUTHORS CONTRIBUTIONS

Zhihui Hou: Concepts, design, data acquisition and analysis, manuscript preparation; Xiang Gao: Case collection, data organization and follow-up, manuscript editing and review; Mingjuan Gu: Study planning and guarantor, manuscript final review, funding acquisition and project management. All authors have read and agreed with the final version of the manuscript.

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CONFLICTS OF INTEREST DISCLOSURE

The authors declare no conflicts of interest.

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Obtained.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

DATA SHARING STATEMENT

No additional data are available.

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