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ORIGINAL ARTICLE

Fractional carbon dioxide laser combined with subcision for the treatment of three subtypes of atrophic acne scars: a retrospective analysis

Xiangying Li[1] · Huiping Fan[2] · Yan Wang[1] · Chao Sun[3] · Xi Yang[3] · Xiaoli Ma[4] · Jing Jiao[3]

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Abstract

Fractional carbon dioxide (CO_2) laser combined with subcision has been widely used for the clinical treatment, but the efficacy of the combined therapy on three types of atrophic acne scars remains unreported. This retrospective study analyzed the clinical data of 413 patients with atrophic acne scars, treated with fractional CO_2 laser combined with subcision in the combined group and with fractional CO_2 laser in the control group. The treatment efficacy was evaluated by the Investigator's Global Assessment (IGA) and the Échelle d'évaluation clinique des cicatrices d'acné (ECCA). We reported adverse reactions such as erythema, lump, skin sensitivity, acne recurrence, and hyperpigmentation that occurred in both treatment groups. The treatment efficiency of the combined group was significantly higher than that of the control group ($P < 0.001$). Among the three subtypes of atrophic acne scars, the ECCA scores in the combined group of boxcar-type and rolling-type scars after treatment were lower than those in the control group ($P = 0.041$, $P < 0.001$, respectively), and no statistical difference in scores between the two groups for icepick-type scars was seen ($P = 0.062$). There was no statistical difference in adverse reactions between the two groups ($P = 0.361$). Fractional CO_2 laser combined with subcision is more effective than fractional CO_2 laser in the treatment of boxcar-type and rolling-type scars, but there is no significant difference in the treatment of icepick-type scars.

Keywords Acne scars · Icepick-type scars · Boxcar-type scars · Rolling-type scars · Subcision · Fractional CO_2 laser

Introduction

Acne vulgaris affects 85% of young people aged 12 to 25 and is one of the 10 most prevalent diseases worldwide [1, 2]. The most common complication of acne vulgaris is the atrophic acne scar, which has the significant psychosocial impact on the patient in terms of embarrassment and self-consciousness. The negative impact of atrophic acne scars increases as the severity of the scar increases [3, 4]. Atrophic acne scars can be divided into three types depending on the depth and width of the lesion: icepick-type, boxcar-type, and rolling-type [5]. Of the three types, the predominant type of atrophic scars is the icepick-type (approximately 60%), followed by the boxcar-type (approximately 25%), and the rolling-type (approximately 15%) [6].

Common treatments for atrophic acne scars include laser, subcision, chemical peeling, filler, microneedle, radiofrequency, and fat injection [7]. Acne scars come in a variety of shapes and depths and can be treated with a combination of treatments to achieve the satisfying result. The gold standard for the treatment of atrophic scars is the ablative fractional carbon dioxide (FCO_2) laser [8]. It induces the reepithelialization of keratinocytes and the production and rearrangement of collagen in the dermal tissue by creating micro-columnar vaporization zones and thermally coagulated necrotic zones in the tissue [9]. Some studies have shown the fractional CO_2 laser is more effective for the

✉ Jing Jiao
jj3286@zxyy.cn

1 Department of Dermatology, Jinan Central Hospital, Shandong University, Jinan, China

2 Department of Dermatology, Central Hospital Affiliated to Shandong First Medical University, Jinan, China

3 Department of Dermatology, Jinan Central Hospital, 105 Jiefang Street, Jinan 250013, China

4 Research Center of Basic Medicine, Jinan Central Hospital, Shandong University, Jinan, China

rolling-type scars than the boxcar-type scars and less effective on the icepick-type scars [10, 11].

Subcision is a safe treatment for acne scars that can be combined with other treatments. The mechanisms of improving acne scars involve releasing the fibrous strands under the scar, organizing blood in the resultant dermal pocket and forming connective tissues in the area [12, 13]. Fractional CO_2 laser combined with subcision has been reported to be superior to the single fractional CO_2 laser treatment in the improvement of atrophic acne scars [14].

The efficacy of fractional CO_2 laser combined with subcision for three subtypes of atrophic acne scars remains unreported. Here, we collected the clinical data of patients to investigate the efficacy and safety of fractional CO_2 laser combined with subcision for the treatment of atrophic acne scars, as well as the efficacy analysis of the combined treatment for the three subtypes.

Materials and methods

Clinical data

A total of 413 patients with atrophic acne scars who received either fractional CO_2 laser combined with subcision or single fractional CO_2 laser treatment in the dermatology department of the author's hospital from October 2020 to October 2022 were selected. Different doctors preferred different treatments, and patients who received the combined treatment were classified as the combined group, and those who received fractional CO_2 laser treatment were classified as the control group. The selected patients were all treated by the same physician.

Inclusion criteria are the following: (1) patients who met the diagnostic criteria and had been diagnosed with atrophic acne scars; (2) patients who received 1–3 sessions of fractional CO_2 laser combined with subcision or fractional CO_2 laser treatment at the author's hospital; (3) patients without inflammatory acne and acute infectious skin diseases on the face; (4) patients aged 18 to 40 years; (5) patients with Fitzpatrick skin type III to IV; and (6) patients with complete clinical data and follow-up data.

Exclusion criteria are the following: (1) patients with keloidal tendency; (2) photosensitive patients; (3) patients with uncontrolled acne vulgaris; (4) patients with active infectious skin diseases; (5) patients with severe underlying diseases such as respiratory diseases, circulatory diseases, digestive diseases, malignant tumors, or immunodeficiency diseases; (6) patients with the history of psychiatric disorders; (7) patients who had been treated with photosensitizing drugs within 3 months before and after or during the course of treatment; (8) patients who had been treated with other types of laser, intense pulsed light, surgery, chemical peeling, dermabrasion, or injection on the face within 3 months before or after the treatment or during the treatment; (9) patients with hypersensitivity to compound lidocaine cream or recombinant bovine basic fibroblast growth factor gel; (10) pregnant or breastfeeding patients; and (11) patients who are unable to follow medical advices for postoperative care.

Treatment

Preoperative preparation: All patients signed the informed consent form. After the patient had cleaned the facial skin, photographs of the patient's front, left (90° angle), and right (90° angle) sides of the face were taken with a fixed camera under the same light in a fixed room and archived. The compound lidocaine cream (Tongfang Pharmaceutical Group Co., Ltd., Chinese medicine standard H20063466) was applied evenly to the atrophic acne scar areas of the patient's face, and the cling film was sealed for 1.5 h for local anesthesia.

Intraoperative treatment: The area of the facial atrophic acne scars was routinely disinfected. The control group was treated with a fractional CO_2 laser device with a wavelength of 10,600 nm (Lutronic eCO2 Plus^{TM}). During the treatment, the pulsed energy of 30–50 mJ was used with the spot density of 100 spots/cm^2 in static operation mood. The treatment parameters were adjusted according to the patient's tolerance level, the Fitzpatrick type, and the location and extent of the acne scar. In the combined group, the disposable syringe needle was used for subcision. The needle was inserted into the dermal-subcutis junction along the edge of the patient's facial scar using a flat stabbing technique. The fibrous bundles were separated by slow fanning movements. Fractional CO_2 laser treatment was then performed, with the same treatment as the control group.

Postoperative care: After the treatment, the patient was immediately given near-infrared (830 nm) light (Lutronic Healite IIC^{TM}). During the treatment, the intensity was level 3, the energy density was 20 J/cm^2, and the treatment time was 6 min and 7 s. The recombinant bovine basic fibroblast growth factor gel (Zhuhai Essex Bio-Pharmaceutical Co., Ltd., Chinese medicine standard S20040001) was applied evenly over the treated area to a thickness of about 1 mm, then covered with a hyaluronic acid bio-dressing, while an ice pack was given for 20 min to apply a cold compress. This treatment was continued for 3 days. There would be a crusting period for 1 week after treatment. Patients were advised not to touch the treated area with water for 3 days, not to scratch the treated area, and to avoid bright light or infection. Each treatment was spaced at least 3 months apart. After 1 month and 3 months of treatment, the operator team communicated with the patients via WeChat to briefly follow up on patients' postoperative outcomes and adverse reactions. We

clarified whether the patients had adverse reactions through face-to-face consultation and provide patients with measures for the management of the adverse reactions. After 3 months of treatment, patients were photographed at the follow-up visit to record the recovery of scars.

Evaluation and data extraction

The efficacy was evaluated by the Investigator's Global Assessment (IGA) scale based on clinical pictures taken before and 3 months after treatment: Grade 0 (no improvement), grade 1 (1–25%), grade 2 (26–50%), grade 3 (51–75%), and grade 4 (76–100%). The total effective rate is calculated as shown in Eq. 1. The nature and number of acne scars were compared between the two groups by the Echelle d'évaluation clinique des cicatrices d'acné (ECCA) scores. The ECCA score is the sum of the weighting factor multiplied by the respective semi-quantitative scores of icepick-type scars, boxcar-type scars and rolling-type scars, superficial elastolysis, hypertrophic inflammatory scars, and keloid scars or hypertrophic scars with the respective weighting scores of 15, 20, 25, 30, 40, and 50. Semi quantitaive score was obtained according to the number or severity of scars: 0 (no scar or absent), 1 (a few scars or mild), 2 (limited number of scars or moderate), and 3 (many scars or intense). The pain score was performed immediately after each treatment, and the patient's subjective pain during treatment was evaluated by the visual analogue scale (VAS). The scale consists of a score of 0 to 10, with 0 indicating no pain and 10 indicating extremely pain. Adverse reactions (ADRs) observed included persistent erythema (lasting more than 1 month), lump (lasting more than 1 month), skin sensitivity (subjective symptom of patients lasting more than 1 month), and acne recurrence and hyperpigmentation (lasting more than 3 months). The incidence of ADRs is calculated as shown in Eq. 2. The ECCA score and the IGA score of the photographs were performed by the doctor in the author's department who were not involved in the treatment and blind to the study.

$$\textit{Total effective rate} = \frac{(\text{Grade 2} + \text{Grade 3} + \text{Grade 4})\ \text{cases}}{\text{total cases}} \times 100\% \quad (1)$$

$$\textit{Incidence of ADRs} = \frac{\text{number of cases with ADRs}}{\text{total number of cases}} \times 100\% \quad (2)$$

Statistical analysis

Statistical analysis was performed on SPSS version 25.0 (IBM). Normally distributed measurement data were shown as mean ± standard deviation (SD) and compared using paired t test. Non-normally distributed measurement data were shown as median (interquartile range; IQR) and compared using the Wilcoxon rank sum test. Categorical data were shown as frequency and proportion (%). Unordered categorical variables were compared using the chi-square test. Ordered categorical variables were compared using the Wilcoxon rank sum test. Differences were statistically significant if $P < 0.05$.

Results

Clinical data of patients in two groups

The clinical data, including age at initial treatment, gender, duration of disease, Fitzpatrick skin type, scar type, location of the lesion, and number of treatment sessions, were collected. There was no statistically significant difference between the two groups for all basic information ($P > 0.05$) (Table 1).

Comparison of clinical efficacy between the two groups

The total effective rate after treatment was 92.09% in the combined group and 77.78% in the control group. The combined group was significantly more effective than the control group ($P < 0.001$) (Table 2).

Comparison of ECCA scores before and after treatment between the two groups

Post-treatment ECCA scores were significantly lower than pre-treatment scores in both groups ($P < 0.001$ for both). There was no statistically significant difference between the pre-treatment ECCA scores of the two groups ($P = 0.292$). The ECCA score after treatment in the combined group was statistically lower than that in the control group ($P < 0.001$) (Table 3). The combined group showed better improvement in acne scars than the control group. We showed comparative photos of the two groups before and after treatment (Figs. 1 and 2).

Comparison of ECCA scores of the three subtypes of atrophic acne scars

The ECCA scores in each group of icepick-type, boxcar-type, and rolling-type atrophic acne scars were statistically lower after treatment compared to the pre-treatment scores in this group ($P < 0.001$). No significant differences in ECCA scores were seen between the two groups in any of the three atrophic acne scars before treatment ($P = 0.081$,

Table 1 Comparison of clinical characteristics between the two groups

Clinical variables		Combined group	Control group	Teat value	*P* value
Gender, *n* (%)	Female	139 (64.65)	134 (67.68)	0.421[a]	0.516
	Male	76 (35.35)	64 (32.32)		
Age(year), mean (SD)		25.14 ± 4.55	25.54 ± 3.89	0.954[b]	0.341
Course(year), median (IQR)		4.00 (5.00)	4.00 (4.00)	0.621[c]	0.535
Fitzpatrick skin type, *n* (%)	III	109 (50.70)	110 (55.56)	0.977[a]	0.323
	IV	106 (49.30)	88 (44.44)		
Scar type, *n* (%)	Icepick-type	51 (23.72)	60 (30.30)	2.272[a]	0.321
	Boxcar-type	88 (40.93)	74 (37.37)		
	Rolling-type	76 (35.35)	64 (32.32)		
Scar site, *n* (%)	Cheek	90 (41.86)	101 (51.01)	5.813[a]	0.055
	Other parts	8 (3.72)	12 (6.06)		
	Cheek + other parts	117 (54.42)	85 (42.93)		
Number of treatment sessions, *n* (%)	1	134 (63.33)	130 (65.66)	5.163[a]	0.076
	2	65 (30.23)	63 (31.82)		
	3	16 (7.44)	5 (2.52)		

SD standard deviation, *IQR* interquartile range

P value > 0.05: non-significant; *P* value < 0.05: significant; *P* value < 0.01: highly significant

[a]Chi-square test

[b]*t* test

[c]Wilcoxon rank sum test

Table 2 Comparison of the clinical efficacy of the two groups

Groups	*n*	Grade 0, *n* (%)	Grade 1, *n* (%)	Grade 2, *n* (%)	Grade 3, *n* (%)	Grade 4, *n* (%)	Total effective rate, *n* (%)
Combined group	215	7 (3.26)	10 (4.65)	112 (52.09)	78 (36.28)	8 (3.72)	198 (92.09)
Control group	198	28 (14.14)	16 (8.08)	115 (58.08)	36 (18.18)	3 (1.52)	154 (77.78)
Teat value		29.376[a]					16.779[b]
P value		< 0.001					< 0.001

P value > 0.05: non-significant; *P* value < 0.05: significant; *P* value < 0.01: highly significant

[a]Wilcoxon rank sum test

[b]Chi-square test

Table 3 Comparison of ECCA scores between the two groups

Groups	*n*	Before treatment, mean ± SD	After treatment, mean ± SD	Test value	*P* value
Combined group	215	124.35 ± 16.19	83.14 ± 19.88	23.56[a]	< 0.001
Control group	198	122.60 ± 17.46	92.35 ± 20.96	15.60[a]	< 0.001
Test value		1.056[a]	4.581[a]		
P value		0.292	*P* < 0.001		

P value > 0.05: non-significant; *P* value < 0.05: significant; *P* value < 0.01: highly significant

[a]*t* test

$P = 0.719$, $P = 0.855$). After treatment, the ECCA scores in the combined group were statistically lower than those in the corresponding control group in both boxcar-type and rolling-type acne scars ($P = 0.041$, $P < 0.001$). No significant difference in ECCA scores was seen between the

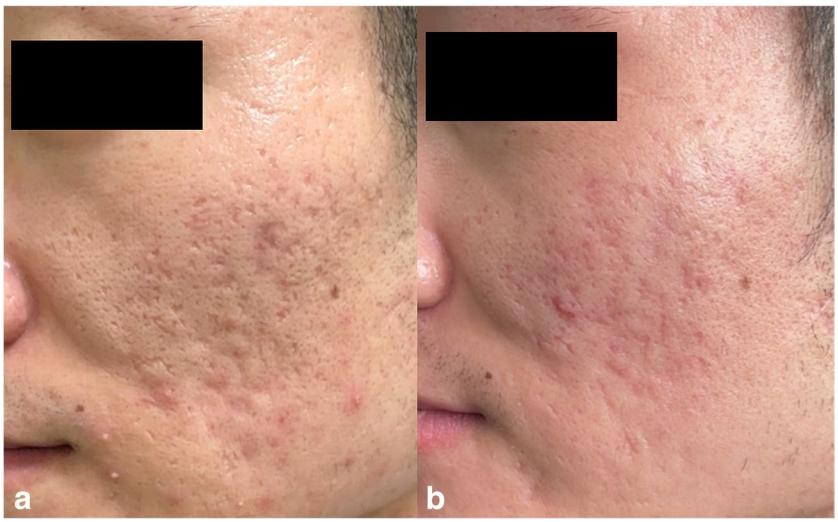

Fig. 1 The case of boxcar-type atrophic acne scar before and after fractional carbon dioxide (CO_2) laser treatment combined with subcision. **a** The patient, male, 22 years old, 4 years of disease course, had an ECCA score of 90 points before treatment. **b** The ECCA score was 50 points at the 3-month follow-up after one session of treatment

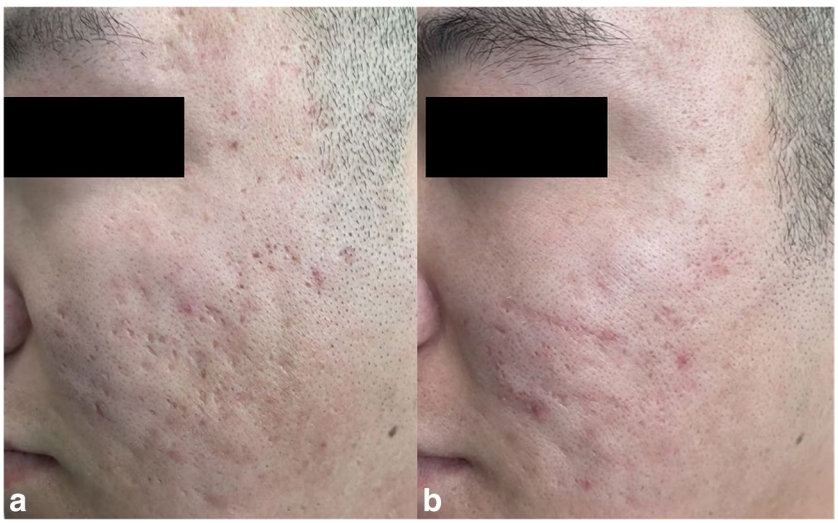

Fig. 2 The case of boxcar-type atrophic acne scar before and after fractional carbon dioxide (CO_2) laser treatment. **a** The patient, male, 25 years old, 5 years of disease course, had an ECCA score of 70 points before treatment. **b** The ECCA score was 35 points at the 3-month follow-up after one session of treatment

Table 4 Comparison of ECCA scores for three subtypes of atrophic acne scars

Subtypes	Groups	*n*	Before treatment, mean ± SD	After treatment, mean ± SD	Test value	*P* vale
Icepick-type	Combined group	51	118.82 ± 18.777	78.43 ± 20.676	10.328[a]	< 0.001
	Control group	60	113.00 ± 15.547	91.75 ± 24.108	5.738[a]	< 0.001
	Test value		1.761[a]	1.882[a]		
	P value		0.081	0.062		
Boxcar-type	Combined group	88	125.45 ± 15.136	88.81 ± 16.678	15.264[a]	< 0.001
	Control group	74	126.35 ± 16.475	94.32 ± 17.287	11.537[a]	< 0.001
	Test value		0.361[a]	2.063[a]		
	P value		0.719	0.041		
Rolling-type	Combined group	76	126.78 ± 14.803	76.64 ± 18.007	18.748[a]	< 0.001
	Control group	64	127.27 ± 16.901	90.63 ± 21.813	10.623[a]	< 0.001
	Test value		0.183[a]	4.087[a]		
	P value		0.855	< 0.001		

P value > 0.05: non-significant; *P* value < 0.05: significant; *P* value < 0.01: highly significant

[a] *t* test

combined group and the control group in icepick-type scars ($P = 0.062$) (Table 4).

Comparison of the incidence of ADRs between the two groups

The level of pain in the combined group was 4 (2) and 4 (2) in the control group, and the difference was not statistically significant ($P = 0.354$). No serious adverse effects were observed in either group after treatment, with some patients experiencing erythema, lump, skin sensitivity, acne recurrence, or hyperpigmentation. The incidence of ADRs was 19.07% (41 cases) in the combined group and 15.66% (31 cases) in the control group. No significant difference in the incidence of ADRs was seen between the two groups ($P = 0.361$) (Table 5).

Discussion

Our study analyzed whether the combination of fractional CO_2 laser and subcision was more effective than the single fractional CO_2 laser in the treatment of the three types of atrophic acne scars. This study will allow for the selection of the appropriate treatment in the clinical work.

Our results showed that the total effective rate was 92.09% in the combined group compared to 77.78% in the control group and that the ECCA score after treatment was statistically lower in the combined group than that in the control group. These results suggest that the combination of fractional CO_2 laser and subcision is more effective than the single fractional CO_2 laser in the treatment of atrophic acne scars. This is consistent with the findings of previous studies [14–17]. Subcision promotes scar repair by breaking the adherent fibers beneath the scar and promoting local collagen fiber remodeling [18]. The reason for the superior efficacy of the combined group over the control group may be the promotion of scar repair by subcision.

It has been reported that subcision combined with other treatments is highly effective in patients with boxcar-type acne scars and rolling-type acne scars [6]. Our study also produced the consistent conclusion that the combination treatment was more effective than the single fractional CO_2 laser treatment for boxcar-type and rolling-type acne scars, while there was little statistical difference in the efficacy of the two treatment groups for deep and steep icepick-type acne scars. Subcision is not as effective for icepick-type acne scars as for boxcar-type acne scars and rolling-type acne scars [19]. This may be related to the depth of the ice pick type, which is deeper than the other two types and can extend vertically into the deep dermis or subcutaneous tissue [19, 16].

We reported adverse reactions such as erythema, lump, skin sensitivity, acne recurrence, and hyperpigmentation that occurred in both treatment groups. The majority of patients' erythema faded within a month. Some patients had hyperpigmentation that remained after the erythema had subsided. With appropriate sun protection, most patients' hyperpigmentation resolved within 3 months. Some patients experienced subjective sensations of skin irritation, most of which disappeared within a month after proper moisturizing care. Asilian et al. showed that the difference in the improvement of scars between blunt and sharp separations was not significant [20]. In our study, a disposable syringe needle was used for sharp separation. This method is convenient and low cost with no significant adverse effects. It has been reported that in order to avoid lumps (proliferative scars) at the site of subcision in patients, the operator needs to perform a precise subcision at the dermal-subcutis junction in order to give the maximum efficacy and safety [6]. In this study, the lumps that appeared in some patients also mostly resolved within a month.

In our study, the IGA score was applied, which is simple to perform but more subjective. The ECCA score is highly objective and is widely used [21–23]. The two assessment methods enhanced the accuracy and credibility of the data.

Table 5 Comparison of the occurrence of adverse reactions between the two groups

Groups	*n*	Erythem, *n* (%)	Lump, *n* (%)	Skin sensitivity, *n* (%)	Acne recurrence, *n* (%)	Hyperpigmentation, *n* (%)	Total occurrence, *n* (%)
Combined group	215	8 (3.72)	7 (3.26)	9 (4.19)	12 (5.58)	5 (2.32)	41 (19.07)
Control group	198	5 (2.53)	1 (0.50)	10 (5.05)	11 (5.56)	4 (2.02)	31 (15.66)
Test value		7.358[a]					7.358[a]
P value		0.189					0.189

P value > 0.05: non-significant; *P* value < 0.05: significant; *P* value < 0.01: highly significant

[a]Chi-square test

However, the treatment frequency of most patients was limited, and the acne scars did not disappear completely in this retrospective analysis. In the combined treatment group, the sample size of the three subtypes of acne scars was small, and the adverse reactions of the three subtypes could not be evaluated. Therefore, a prospective and simultaneous spilt-face study with a longer follow-up and more treatment sessions is needed to evaluate the efficacy and safety of the combination of fractional CO_2 laser and subcision in the treatment of three subtypes of atrophic acne scars.

Conclusion

Our study suggested that the combination treatment of fractional CO_2 laser and subcision could be more effective for boxcar-type and rolling-type acne scars than the single treatment of fractional CO_2 laser, but no significant difference was found for icepick-type acne scars.

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Author contribution Xiangying Li: study design, data collection, data statistical analysis and article writing. Huiping Fan, Yan Wang: assessment of efficacy, graphical processing. Chao Sun, Xi Yang, Xiaoli Ma: study design, article writing. Jing Jiao (corresponding author): treatment operator, study guidance.

Data availability To protect the privacy of patients, raw data is available on request and can available from the corresponding author.

Declarations

Ethics approval This retrospective chart review study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of Jinan Central Hospital approved this study.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication The authors affirm that human research participants provided informed consent for publication of the images in Figs. 1 and 2.

Conflict of interest The authors declare no competing interests.

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