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ORIGINAL RESEARCH

Evaluation of a Novel Microfocused Ultrasound with Three-Dimensional Digital Imaging for Facial Tightening: A Prospective, Randomized, Controlled Trial

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ABSTRACT

Background: The excellent efficacy is mitigated by the limited safety profile of microfocused ultrasound procedures.
Objective: We sought to assess the safety and tightening efficacy of a novel microfocused ultrasound.
Methods: The randomized middle and lower face and submental region of the participants were treated with the novel device using the following transducers: M4.5, D4.5, M3.0, and D3.0. Improvement in paired comparison of pretreatment and posttreatment photographs, three-dimensional (3D) volumetric assessments, skin thickness measured by B-ultrasonography, and skin photoaging parameters were evaluated. Adverse events and patient satisfaction were also recorded.
Results: A total of 20 participants (20 female) were enrolled. Fourteen of 20 participants (70%) were judged to show clinically significant facial tightening during 3-month follow-up ($P < 0.05$). The mean volumetric change in the lower face, as quantitatively assessed after 3 months was −0.29 mL compared with +0.42 mL on the control side ($P < 0.05$). The VAS pain score was 3.00 ± 1.19 without any oral or intramuscular anesthesia.

Jiafang Zhu, Yue Han, and Ying Liu have contributed equally to this work and should be considered co-first authors.

Dongze Lyu and Xiaoxi Lin have contributed equally to this work and should be considered co-corresponding authors.

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Conclusions: A small sample size, lack of clinical scales, and impersonalized treatment parameters. The novel microfocused ultrasound appears to be a safe and effective modality for lower-face tightening.
Clinical Trial Registration Number: ChiCTR 2200064666.

Keywords: Facial contours; Microfocused ultrasound; MicroUltra; Tightening; Tissue remodeling; Volumetric measurement

Key Summary Points

Why carry out this study?

The excellent efficacy is mitigated by the limited safety profile of microfocused ultrasound procedures.

We sought to assess the safety and tightening efficacy of a novel microfocused ultrasound.

What was learned from this study?

The proposed microfocused ultrasound could safe and effectively tighten the facial contour and improve soft tissue accumulation of the lower face in a single treatment.

More precise equipment should be adopted in the future to further accurately evaluate the subtle tightening changes.

INTRODUCTION

Nonsurgical facial rejuvenation procedures have gradually replaced surgical options for mild and moderate facial lifting and tightening [1]. Light-based devices, injections, radiofrequency, and high-intensity focused ultrasound are the main popular options aiming for minimally invasive tissue remodeling, leading to a smoother facial contour and younger appearance [2–5].

Among the aforementioned options, high-intensity focused ultrasound (HIFU) therapy is independent of skin color and can be concentrated in a defined subcutaneous focal area to produce facia contraction and fat cell lipolysis, while sparing the surrounding tissue including vessel and epidermis. Hence, it seems to be an ideal option for tightening the sagging fat pad-induced laxity in the Asian population [6]. The HIFU devices can heat and coagulate the tissue, leading to focal necrosis and cellular damage, initiating an inflammatory cascade that culminates in tissue remodeling and tightening [7]. Studies have shown a satisfactory effect of HIFU on facial and neck tightening [8, 9]. However, the demand for oral or intramuscular anesthesia to overcome unbearable pain has limited its use on the broader population [10]. Blistering, erosion/ulceration, tissue atrophy and necrosis, and nerve injury have been reported occasionally [11, 12]. Improper operation of the device, along with incorrect parameter settings, can lead to more superficial treatment, resulting in side effects [11].

How to increase the comfort and safety of treatment under the premise of ensuring facial tightening efficacy is the focus of current research and development of a microfocused ultrasound system (MFUS).

A novel microfocused ultrasound (MFUS; MicroUltra, Peninsula, Shenzhen, China) was approved by the Chinese National Medical Products Administration for facial contour tightening in 2021. Besides the traditional 4.5-mm and 3.0-mm linear ultrasound-emitting microfocused handpiece, the device was innovated with additional dot ultrasound-emitting microfocused handpieces of the same depth. The ultrasound energy is irradiated in the single dot form rather than a line with a comparatively lower temperature of 50–60 °C, which could be used to safely treat the perioral and preauricular tissues where the nervus mentalis and facial nerve branches are located [13, 14]. Also, the focal area of the dot-emitting transducer was larger with approximately three times the diameter of the linear light-emitting transducer (0.7 mm versus 2–3 mm), which is expected to compensate for the space between the treated lines, leading to more uniform heating and tissue remodeling.

This study used quantitative evaluation tools to evaluate the efficacy and safety profile of the novel MFUS system in terms of skin tightening.

METHODS

Patient Selection

We conducted this clinical, prospective, randomized, split-face study to evaluate the efficacy of the novel MFUS for patients with facial laxity. This study was approved by the Ethical Committee of the Shanghai Ninth People's Hospital. All participants provided informed consent, and the study was conducted in accordance with ethical guidelines for clinical research. Participants were clear that they were free to withdraw at any time if they felt any level of discomfort according the ethics (clinical trial registration number: ChiCTR 2200064666). The procedures followed were in accordance with the Helsinki Declaration of 1964 and its later amendments.

The study was performed at the Department of Laser and Aesthetic Medicine, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, for 12 months (July 2022–July 2023). Healthy individuals aged 25–65 years with mild-to-moderate undesirable sagging fat tissue, which induced localized-to-prominent nasolabial and submandibular folds, were enrolled in the study. The participants were required to have a body mass index (BMI) between 18 and 29 kg/m^2. A normal BMI is required because lipolytic sensitivity is impaired in patients with obesity, defined by BMI $> 30\ kg/m^2$ [15]. The exclusion criteria were as follows: active systemic or local infections; local skin disease that might alter wound healing; scarring in the test areas; psychiatric illness; history of smoking; and insertion of soft tissue augmentation materials or application of ablative or nonablative laser procedures within the previous 6 months. Patients manifesting weight loss throughout the study were excluded from the volumetric measurement analyses because the changes in diet and/or exercise might affect volumetric changes. After reading the experimental protocol and being advised of the treatment risks, all patients gave written informed consent for participation in the study.

Independent statisticians randomized the participants. Based on the randomized enrollment results, half of the face underwent MFUS treatment and the other half remained untreated (control). All participants underwent one treatment. They were evaluated 1, 3, and 6 months after the final treatment.

Equipment and Procedures

The novel MFUS (MicroUltra, Peninsula, Shenzhen, China) was adopted in the study. Two handpieces (microfocused handpiece and dot handpiece) with four transducers were used for treating facial and neck laxity: microfocused 4.5 transducer (M4.5) and dot 4.5 transducer (D4.5) with a focal depth of 4.5 mm and frequency of 4 MHz; microfocused 3.0 transducer (M3.0) and dot 3.0 transducer (D3.0) with a focal depth of 3.0 mm and frequency of 4 MHz. The power of the device could be adjusted from level I to level V, with power adjusted from 1.32 to 6.63 W. The frequency of the dot handpiece could be adjusted from 5 to 10 Hz.

Silica Gel Phantom and Histometric Evaluation

We initially examined treatments with the four MFUS transducers on silica gel phantom due to its homogeneous composition to analyze the geometric patterns of TCPs induced by HIFU treatment.

Each HIFU transducer treated the prepared silica gel phantom using the 6.63 W (level V). The probes of the microfocused handpiece were uniformly set to a length of 20 mm with an interval of 2 mm to emit one pass in a linear array, while the probes of the dot handpiece were set to emit a single pulse. After delivering a single pulse of HIFU treatment on the phantom tissue, high-speed digital photographs were taken to measure the focal depth of the TCP using the ruler beside the phantom.

In this study, to test the safety of the probe, we used fresh, normal upper eyelid skin tissue donated by an 8-year-old patient who had undergone flap surgery. The tissue was legally obtained from the Department of Plastic and Reconstructive Surgery of our hospital. The M3.0 probe was uniformly set to a length of

20 mm with an interval of 1.2 mm to emit six passes in a linear array at the same place on the donated skin. The samples were fixed with 10% buffered formalin and embedded in paraffin. Approximately 200 serial skin sections at a thickness of 4 μm were prepared and stained with hematoxylin and eosin for evaluating 6 passes of M3.0 interactions in the skin.

Treatment Procedures

All participants were treated without topical anesthesia. They were set to receive the highest level of the device to test the safety of the whole system. They were treated using M4.5, 6.63 W (level V), with 150 lines on the lower face and submental area; D4.5, 6.63 W (level V), 10 Hz, with 4800 dots performed in 8 min on the lower face and the perioral and preauricular areas; M3.0, 6.63 W (level V), with 150 lines on the lower face and submental area; D3.0, 6.63 W, 10 Hz, with 6000 dots on the lower face, submental area, and middle face. The microfocused probes were uniformly set to a length of 25 mm with an interval of 1.5 mm. A total of 300 lines and 10,800 dots were performed on the randomly selected half lower two-thirds of the face following the suggested treatment lines and zones provided by the manufacturer (Fig. 1A–D).

Assessment

Subjective Assessment

Clinical efficacy measures included the physician and participant Global Aesthetic Improvement Scale (GAIS). This involved comparing digital images (70D camera, Canon, Tokyo, Japan) of the participant before treatment and at intervals of 1, 3, and 6 months after treatment. Ratings were assigned as follows: +3 (very much improved), +2 (marked improvement), +1 (improved), and 0 (no change), or −1 (worse), −2 (marked worse), and −3 (very much worse). The FACE-Q scale for lower face and jawline was further used to confirm the improvement in sagging by the participants [16–18].

Objective Assessment

Three-Dimensional Imaging System

A three-dimensional imaging system (3dMDface system; 3dMD Inc., GA, USA) was used for the objective analysis at baseline and after 1, 3, and 6 months. This system could capture the changes in skin topography. It could accurately record facial topography in less than 1.5 ms even if the subject could not maintain perfect stillness. The system error was less than 0.2 mm, the image processing error was about 1.5% of the total measurement error, and the measurement repeatability was more than 80%.

Each face scan was imported into the Geomagic Design X 3D software (2020, 3D Systems, Raindrop Geomagic GmbH, NC, USA). For each patient, the software used an automatic alignment function to superimpose the pretreatment and posttreatment scans, subsequently generating enhanced 2D color representations. The differences in facial tissue volume before and after treatment were demonstrated via 3D schematics, with relative degrees of facial tightening represented by light-blue to dark-blue zones (dark blue, −2 mm change).

All images were obtained using consistent lighting, participant positioning, and focus. The tightening of the lower face and submental area was evaluated on the basis of volumetric changes in the preestablished area of interest (AOI). All the calculations were done using the fixed images from the three-dimensional imaging system with computer analysis.

The area of interest of the lower face was connected by the anatomical marks as follows: intertragal incisura (I), oral corner (OC), premaxillary (PM), and mandibular angle (MA) and top of the earlobe (E).

The area of interest of the submental area was connected by the anatomical marks as follows: submental point (SM) and MA. One landmark (MC) was placed below SM at the and the point where the chin meets the neck and another point (P) was placed 10 mm below MA. The line segment connecting PM and MA followed the participant's submental contour (Fig. 2A and B).

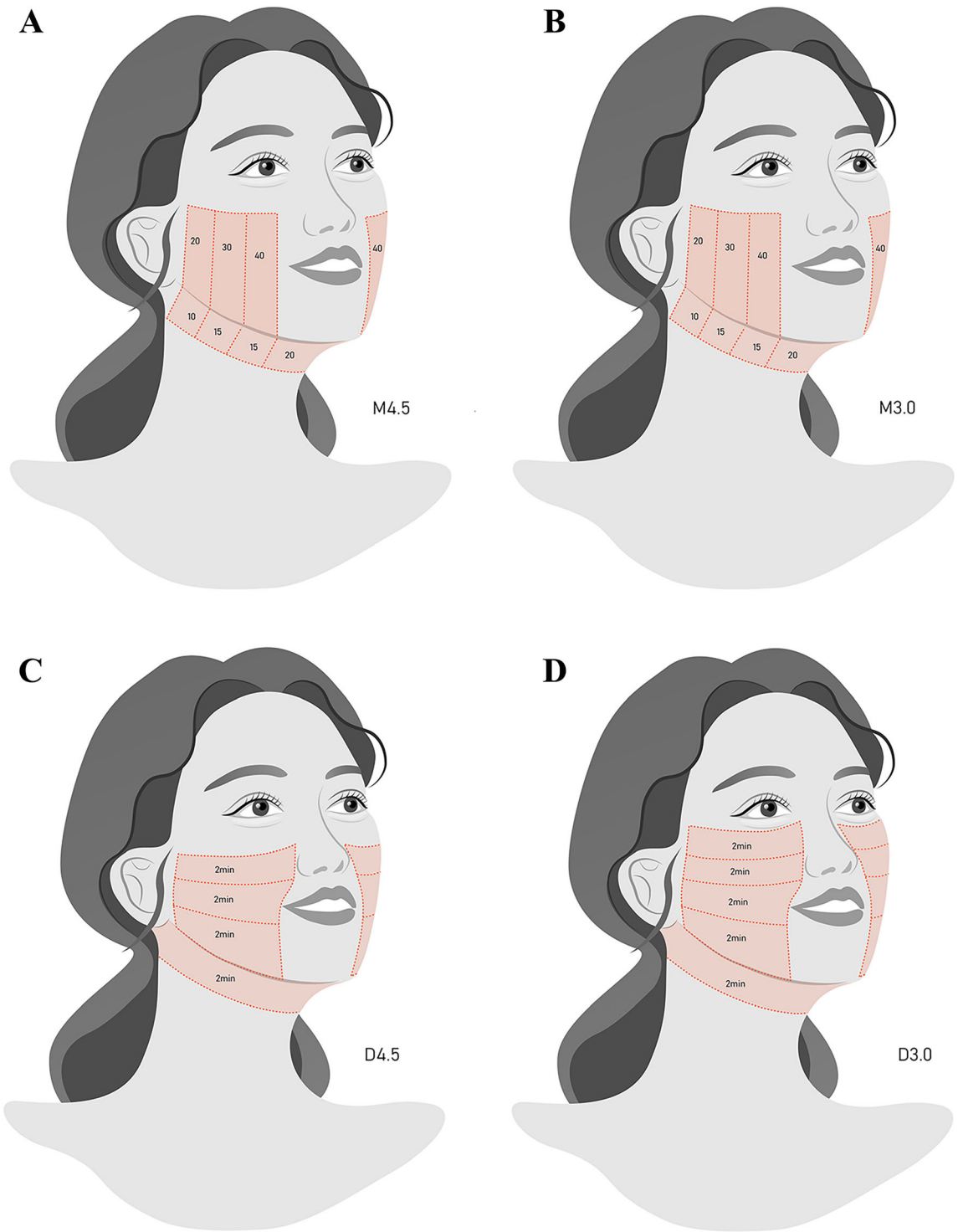


Fig. 1 **A–D** Microfocused ultrasound system transducer selection and treatment exposure lines of the microfocused handpiece (**A** and **B**) and treatment exposure time of dot handpiece at a frequency of 10 Hz (**C** and **D**) based on facial topography

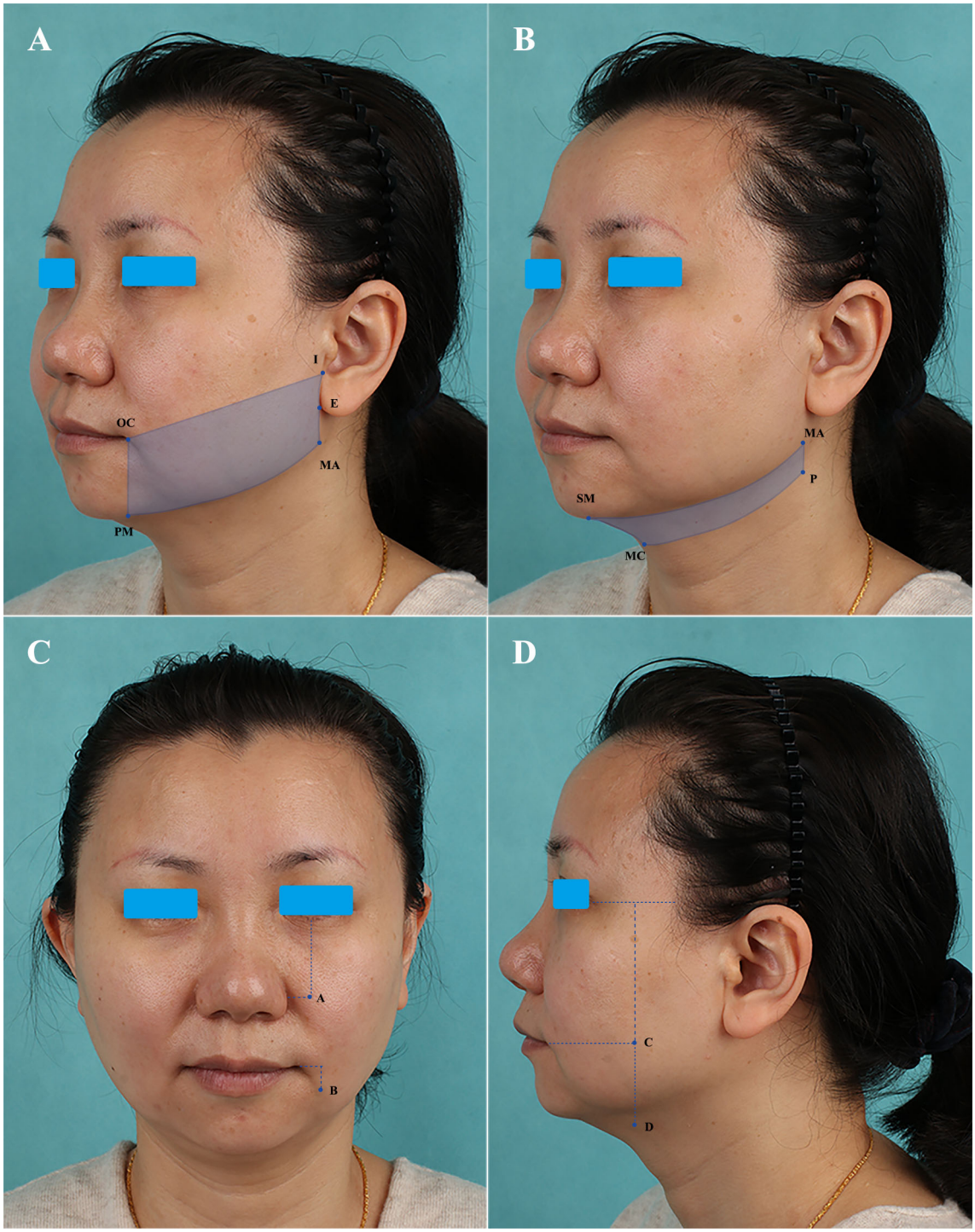


Fig. 2 **A** and **B** Lower face and submental tightening were evaluated using volumetric changes in the preestablished area of interest. **C** and **D** On ultrasound images, the depth of skin and subcutaneous tissue of the selected landmarks **A**–**D** was measured

The volumetric changes of AOI were calculated using the Geomagic Design X 3D software.

US Examination

Sonography was performed before the treatment using the GE-Voluson E 8 instrument (GE Healthcare, Austria) and MyLabClassC (Esaote, Italy), with a broadband (9–14 MHz) linear transducer. In gray-scale ultrasound (US) images, we measured the depth of the skin and subcutaneous tissue at specific reference points (landmarks A–D). Landmark A was about 1 cm away from the wing of the nose, which referred to sagged superficial medial cheek fat. Landmark B was 1 cm below and outside the mouth corner, which referred to sagged buccal fat leading to the marionette fold. Landmark C was the junction of the middle of the temporal part and the mouth corner, which referred to the sagged fat leading to the sagged jawline. Landmark D was 1 cm below the mandible and in a vertical line with C, which referred to sagged submental fat. The depth of the subcutaneous fat of landmarks A and B was measured from the bottom of the dermis to the middle of the superficial musculoaponeurotic system (SMAS), and landmarks C and D measured the whole depth of the subcutaneous tissue (Fig. 2C and D).

The same technician who was blinded to the treatment performed measurements in a supine position. The technician was asked to apply the probe gently without compressing the skin tissue.

Skin Photoaging Parameters

Standardized photography was obtained at baseline and during each follow-up visit using the MindScan (Bose Electronic Co., Wuhan, China). Photographs were captured with standard lighting, cross-polarization, parallel polarization, and ultraviolet light in right lateral 45°, left lateral 45°, and frontal views. Skin photoaging parameters, including wrinkles, texture, dilated skin pores, and brown spots, were evaluated and recorded.

Safety and Side Effects

During the treatment, the participants rated their pain sensation severity using a validated 11-point visual analog scale (VAS) (0–10), with 0 denoting no sensation and 10 denoting the worst possible pain. The side effects were recorded.

Sample Size

Referring to the literature, the score of GAIS increased by 2.43 and the standard deviation was 0.81 compared with that 6 months after focused ultrasound treatment. The statistical power value of this sample size was verified using PASS software: $\alpha = 0.05$ and differences of 2.47, resulting in a power of 0.999. The rate of loss of follow-up was set at 20%, and the final number of participants was 20.

Data Analysis

All data were analyzed using SPSS 27.0 (IBM, NY, USA) and GraphPad Prism 8 (GraphPad Software, Inc., CA, USA) to evaluate the effectiveness. The continuous variables were described as the mean ± standard deviation, and the stratified variables were described as the median ± quartile. For group comparisons, the paired-sample *t*-test was performed for normally distributed continuous variables, and confidence intervals (CI) and effect sizes (ES) were calculated to complement the *P*-values provided. While the Wilcoxon paired-sample rank-sum test was used for the non-normally distributed continuous variables. The level of significance was set at $P < 0.05$.

RESULTS

Silica Gel Phantom

The TCPs induced by the transducers were wedge shaped. The TCPs induced by M3.0 and D3.0 had an approximately 1.5–5.5 mm depth, with the most confined focused depth at 2–3.5 mm. However, the TCPs induced by M4.5

and D4.5 had an approximately 2.5–7.0 mm depth, with the most confined focused depth at 3–4.5 mm and 3–5 mm (Fig. 3A–D).

The histopathological examination demonstrated coagulation of facia and fat cell lipolysis, sparing the dermis and epidermis even if the probe fired six passes. The depth of the TCP on facia was measured at an average of 2.00 mm (M3.0, 6.63 W, 50 ms, 6 passes) (2003.30 ± 239.60 μm; mean ± SD; minimum 1649.80 μm; maximum 2401.40 μm). The height of the TCP was approximately 858.00 μm (Fig. 3E and F).

Participants

All 20 participants completed one treatment and underwent the follow-up examinations after 1, 3, and 6 months. The demographics of patients are presented in Table 1. All the participants were female. The mean patient age was 46.45 ± 8.89 years (range 30–58 years). The mean BMI of the patients was 23.05 ± 2.75 kg/m^2 (range 18.25–28.70 kg/m^2). The Fitzpatrick skin type of 15 and 5 participants was type III and type IV, respectively.

Efficacy and Safety

Subjective Assessment

The GAIS scores of both the physician and the participants improved after 1, 3, and 6 months. The median of participant GAIS score was 2.00 ± 1.00 ($P < 0.001$), 2.00 ± 2.00 ($P < 0.001$), and 2.00 ± 1.25 ($P < 0.001$) at 1-, 3-, and 6-month follow-up. The participant FACE-Q score for lower face and jaw increased from 34.00 ± 10.50 before treatment to 66.00 ± 20.00 ($P < 0.001$), 66.00 ± 30.50 ($P < 0.001$), and 72.00 ± 32.00 ($P < 0.001$) at 1-, 3-, and 6-month follow-up.

The median of GAIS score of the blinded investigator was 0.33 ± 0.63 ($P < 0.05$), 0.67 ± 0.92 ($P < 0.05$), and 0.67 ± 0.36 ($P = 0.56$) for the treated side compared with 0.00 ± 0.00, 0.00 ± 0.00, and 0.00 ± 0.50 after 1, 3, and 6 months, respectively. The overall accuracy for the three blinded physicians to pick the right sides of treated was 70%.

Objective Assessment

Three-Dimensional System Analysis

The 3D volumetric assessments showed a reduction in the volume of AOI on the lower face compared with the pretreatment volumes. The average volume change of the AOI on the lower face was −0.24 ± 1.03 mL [ES 0.58, 95% confidence interval (CI) 0.10–1.05, $P < 0.05$] after 1 month, −0.29 ± 0.94 mL (ES 0.67, 95% CI 0.18–1.15, $P < 0.01$) after 3 months, and −0.22 ± 1.01 mL (ES 0.29, 95% CI −0.16 to 0.73, $P > 0.05$) after 6 months, which was statistically significant for 1 and 3 months compared with 0.09 ± 0.83 mL, 0.49 ± 1.40 mL, and 0.06 ± 1.14 mL at 1, 3, and 6 months, respectively, on the control side. However, the volumetric change in the submental area was not statistically significant, with values of –0.18 ± 2.31 (ES 0.02, 95% CI −0.42 to 0.46, $P > 0.05$), 0.42 ± 1.79 (ES 0.09, 95% CI −0.35 to 0.53, $P > 0.05$), and 0.27 ± 1.25 (ES −0.11, 95% CI −0.55 to 0.33, $P > 0.05$) compared with −0.16 ± 1.93, 0.51 ± 2.01, and 0.23 ± 1.32 after 1, 3, and 6 months, respectively.

Figures 4 and 5 show the typical volumetric changes before treatment and 3 months after treatment.

US Findings

The mean skin thickness for A, B, C, and D was 1.99 ± 0.46 mm, 1.63 ± 0.27 mm, 1.62 ± 0.27 mm, and 1.53 ± 0.25 mm, respectively, before treatment; no statistically significant increase in skin thickness was detected after treatment. However, the mean subcutaneous fat thickness for A, B, C, and D was 4.91 ± 1.00 mm, 4.87 ± 1.13 mm, 3.99 ± 1.26 mm, and 4.27 ± 1.07 mm, respectively, before treatment, which was significantly reduced compared with that on the control side (Fig. 6A–D).

Skin Photoaging Parameters

Four among eight variables in skin complexion analysis were evaluated: wrinkles, texture, pores, and brown spots. The quantitative value

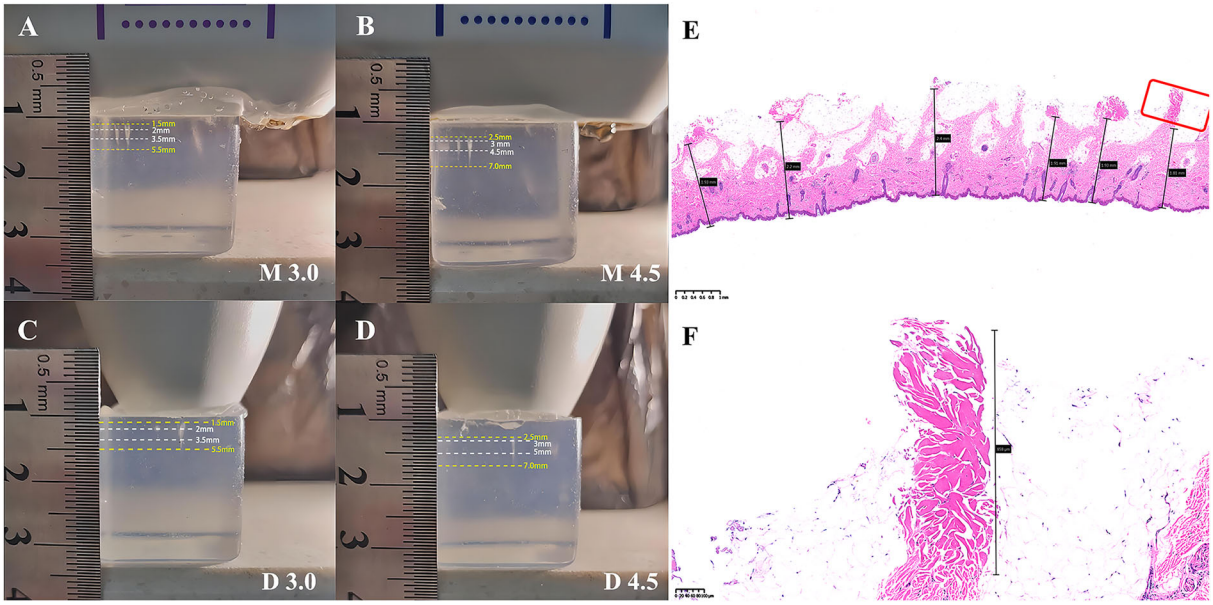


Fig. 3 **A–D** TCPs induced by the transducers were wedge shaped. **E**, **F** On histologic examination, thermal coagulation was observed when facia was involved within TCP. Thermally damaged fat cells were observed beside the facia. The dermis and epidermis were not affected

Table 1 Participant characteristics

Demographic	Mean ± SD (median) (min–max) or *n* (%)
Age, years	46.4 ± 8.9 (49) (30–58)
Body mass index, kg/m^2	23.1 ± 2.75 (22.9) (18.2–28.7)
Sex	
Female	20 (100)
Fitzpatrick sun-reactive skin type	
III	15 (75)
IV	5 (25)

in wrinkles, pores, and brown area score was statistically significant 1, 3, and 6 months after treatment compared with that before treatment (Table 2). However, the reduction values were not statistically significant compared with those in the control group (Table 3).

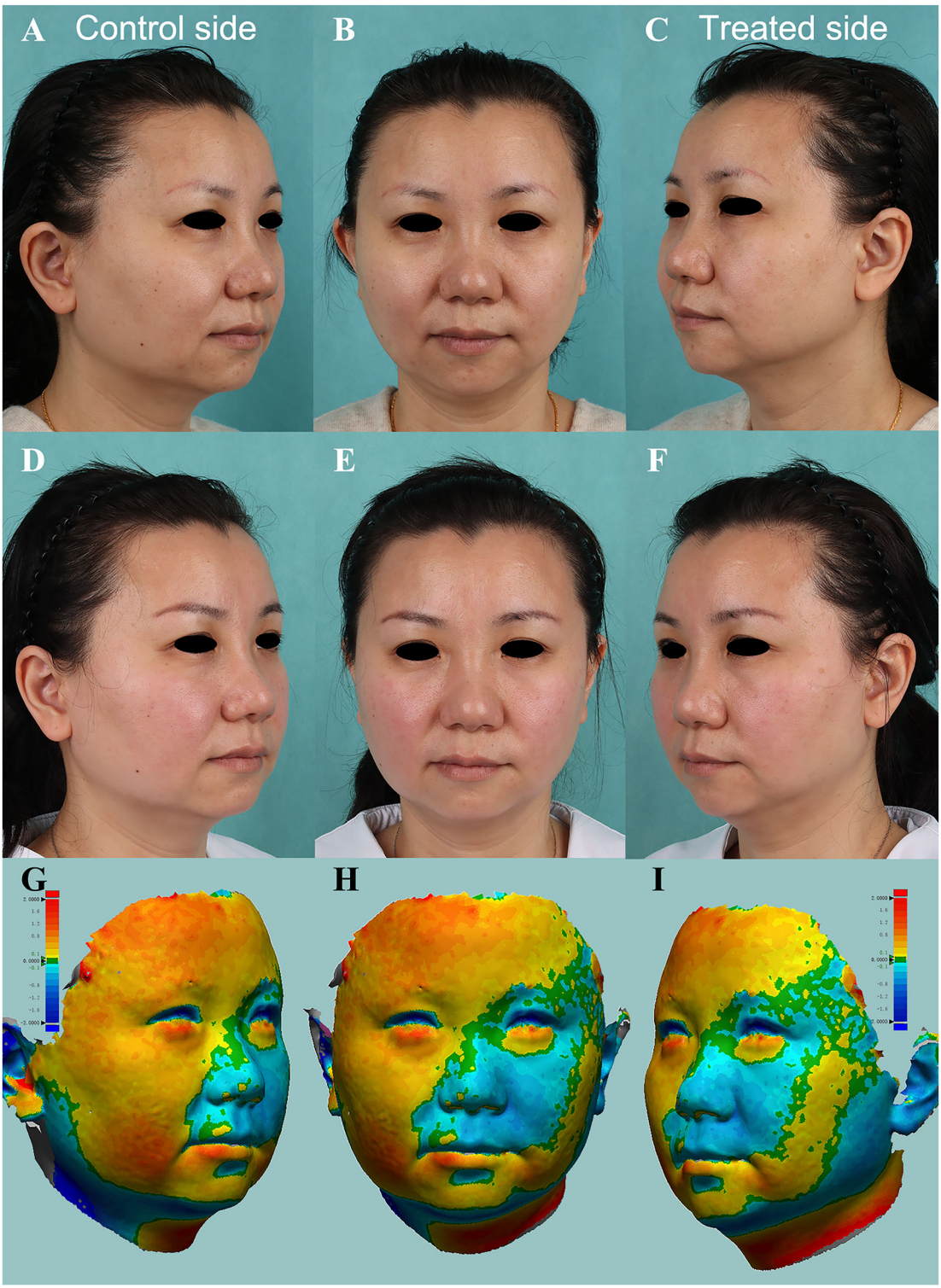
Safety

During the treatment, the median of VAS pain score was 3.00 ± 1.19 (range 1.5–3.5). The participants did not require any pre- or posttreatment pain relief products.

All the participants experienced slight erythema and edema, lasting 2–48 h after treatment. Another most common adverse event was allodynia without abnormal appearance over the treated area, usually lasting 14 days after treatment. None of the participants reported paresthesia, numbness, or tingling after the treatment.

DISCUSSION

A 4.5-mm focal depth transducer induces fractional, subtle thermal damage within the SMAS layer and deep fat tissue, which primarily inducing lifting of facial contour., While a 3.0-mm focal depth transducer causes similar damage in the superficial fat layer and facia, inducing the tightening of facial contour


A Control side
B
C Treated side
D
E
F
G
H
I

◀**Fig. 4** Representative photographs of the results using the microfocused ultrasound system. **A–C** A 48-year-old female patient before treatment and **E–G** 3 months after treatment. **H–J** Superimposed three-dimensional (3D) volumetric assessment comparing the values before treatment and 3 months after treatment. Mild tightening effects were observed on the treated side in 2D color digital photographs after treatment compared with those before treatment. Tightening effects on the lower one-third of the face and the inner cheeks were induced by the treatment, which persisted for 6 months. Volumetric reduction on the lower face in 3D volumetric assessment was observed 3 months after treatment compared with that before treatment (treated side −0.17 mL versus control side 1.56 mL). The varying degrees of tightening achieved are shown in colors ranging from light blue to dark blue (−2.0 mm). Tightening effects on the lower one-third of the face and the inner cheeks were induced by the treatment, which persisted for 6 months (treated side −0.12 mL versus control side 0.81 mL)

[6, 19, 20]. The histological examination confirmed fat cell lipolysis and superficial fascia coagulation under M3.0 probe firing. The 3D imaging results suggested the volume reduction began after 1 month, became most prominent after 3 months, and sustained through 6 months after treatment. The period required might be related to the complete removal of necrotic fat cells by the macrophages [19].

The volumetric changes in the mandibular area did not decrease significantly, as reflected by 3D data, which was inconsistent with previous findings [5, 21, 22]. This might be attributed to the failure of participants to strictly control their diet, resulting in the increase in the size and number of fat cells and their accumulation in the lower jaw. Patients were found to gain an average of 0.20, 1.20, and 0.80 kg at 1, 3, and 6 months, respectively, after treatment.

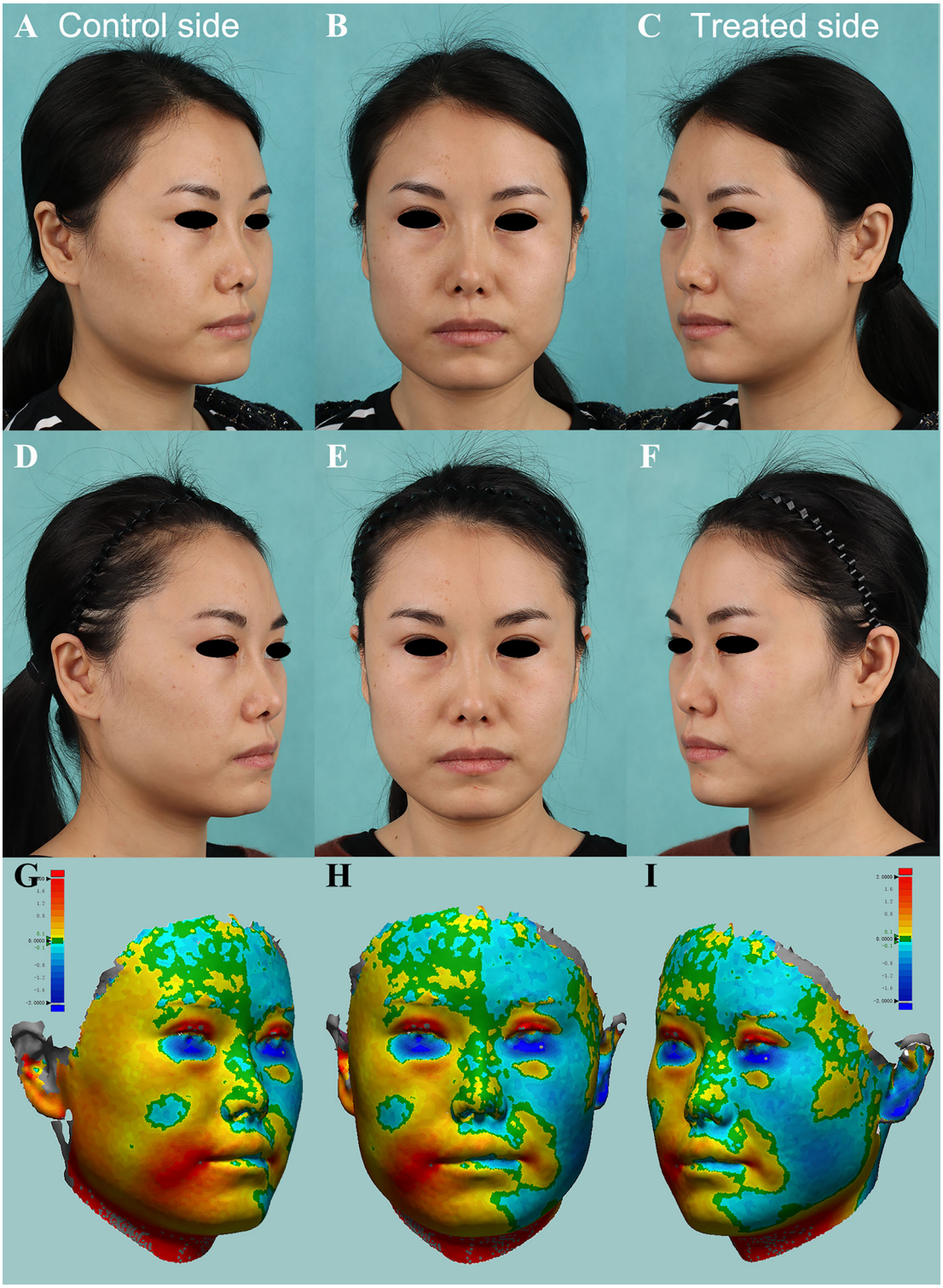
We also found that the thickness of the lower facial skin and tissue of volunteers in the range of 5–7 mm displayed a better clinical result. After compressing the tissue during treatment, the tissue thickness was reduced to 4–5.6 mm due to the compression rate of about 80%; this was the depth targeted by most shots of the transducer. Subjects with overweight might have plenty of fat cells that are not sensitive to heat, while the transducer might be beyond the therapeutic range of participants with underweight to act on the muscle, bone, or deeper fat tissue instead of on the superficial subcutaneous tissue, thus resulting in no obvious improvement.

In terms of safety profile, no topical or intramuscular anesthetics were needed, while a comparatively low pain degree of 3 out of 10 was reported. On the one hand, a single firing pulse was comparably short, with a pulse width of less than 50 ms. The extremely short pulse reduced the duration for pain sensation. On the other hand, dot transducers adopted a larger ultrasound focal plane, resulting in more heating of the tissue than coagulation. The operating temperature induced by dot transducers fluctuated between 50 °C and 60 °C (Supplementary Fig. 1), which was enough to reduce fat cell viability by 80% even after one-minute irradiation [23]. Epidermis and dermis were well preserved either in vivo after treatment or ex vivo observed through histological evaluation.

Previous studies suggested that the skin could be thickened with 4.5-mm and 3.0-mm transducer only, but this was not confirmed in our study [24, 25]. It might be because the focal depth of the transducer differed among devices. In our study, the focal depth of the M3.0 transducer was 2–3 mm, exceeding the mean skin thickness in our study, which ranged from 1.53 to 1.99 mm, which was not superficial enough to coagulate and remodel dermis tissue. However, the photoaging parameters including wrinkle, enlarged facial pores, and brown area decreased significantly on both sides posttreatment, indicating other mechanism may exist in MFUS rejuvenation results.

The GAIS scores of the evaluators were lower than those of the participants, suggesting effects that the naked eye could not accurately identify, considering only changes of more than 0.5 mm could be identified by blinded investigator [8, 26].

The lack of clinical scales was one major limitation since potential bias between different clinicians without standardized scale might be introduced to the results. Introducing laxity scales such as Fasil Face/Upper Neck Laxity Scale


A Control side
B
C Treated side
D
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◀**Fig. 5** Representative photographs of the results following the microfocused ultrasound system. **A–C** A 37-year-old female patient before treatment and **E–G** 3 months after treatment. **H–J** Superimposed three-dimensional (3D) volumetric assessment comparing the values before treatment and 3 months after treatment. Volumetric reduction on the lower face in 3D volumetric assessment was observed 3 months after treatment compared with that before treatment (treated side −0.20 mL versus control side 0.21 mL). The varying degrees of tightening achieved are shown in colors ranging from light blue to dark blue (−2.0 mm). Tightening effects on the lower one-third of the face and the inner cheeks were induced by the treatment, which persisted for 6 months (treated side −1.13 mL versus control side −0.51 mL)

[27] and Scale Assessment of the Facial Age [28] would certainly increase consistency between clinicians and establish standards for laxity measurement. Further study would introduce such scales to increase objectivity. Also, although the MindScan and 3D camera were used, bias was possible due to micro-expression changes and subtle head movement. More precise equipment should be adopted in the future to further accurately evaluate the subtle changes, which could hardly be distinguished by the investigator.

LIMITATIONS

This study had certain limitations, such as a small sample size with only female subjects enrolled, a short-term follow-up, and possible measurement bias by blinded examiners. In the future, we will further expand the sample size with male subjects enrolled and conduct longer-

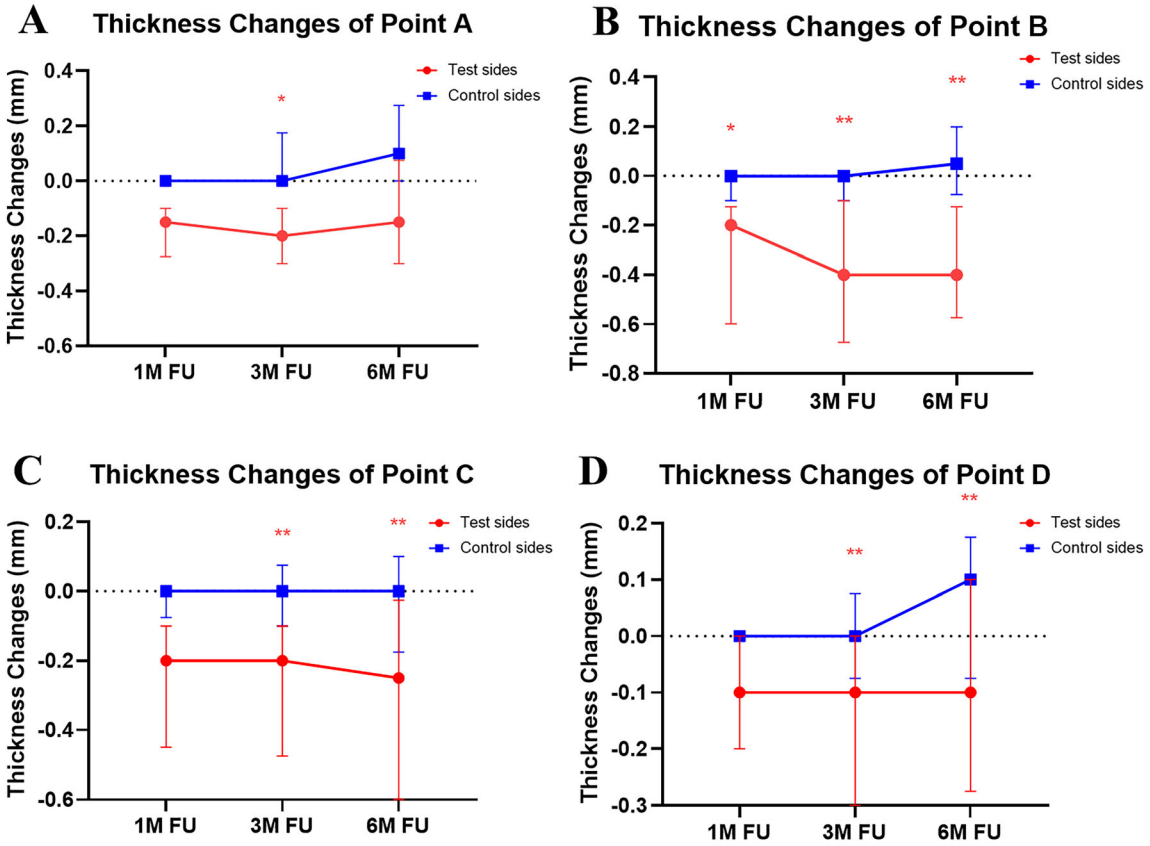

Fig. 6 **A–D** Thickness changes in subcutaneous fat on US images. The thickness of subcutaneous fat significantly decreased compared with that point **A–D** on the inner cheek, mental, lower face, and mandibular area on the control side

Table 2 Differences in pigment, texture, wrinkle, and enlarged facial pores on the treated side

	Mean (SD)	*P* value	ES	95%CI
Wrinkles				
Baseline	170.14 (89.95)			
1 M FU	149.66 (85.22)	$P < 0.001$	1.19	0.60, 1.76
3 M FU	134.07 (77.29)	$P < 0.001$	1.35	0.73, 1.96
6 M FU	120.82 (71.81)	$P < 0.001$	1.47	0.83, 2.11
Pores				
Baseline	671.80 (333.06)			
1 M FU	586.55 (290.81)	$P < 0.01$	0.78	0.27, 1.27
3 M FU	528.80 (278.11)	$P < 0.001$	1.20	0.61, 1.77
6 M FU	472.20 (280.21)	$P < 0.001$	1.26	0.66, 1.85
Brown spots				
Baseline	389.02 (141.27)			
1 M FU	327.83 (138.88)	$P < 0.01$	0.84	0.32, 1.34
3 M FU	305.31 (111.65)	$P < 0.001$	1.29	0.68, 1.88
6 M FU	293.82 (107.45)	$P < 0.001$	1.53	0.57, 1.71

CI confidence intervals, *ES* effect sizes

Table 3 Differences in pigment, texture, wrinkle, and enlarged facial pores between treated and control sides

	Pigment difference		Texture difference		Wrinkle difference		Enlarged facial pore difference	
	Test	Control	Test	Control	Test	Control	Test	Control
1 M FU	−53.44 (79.72)	−17.53 (62.60)	1.01 (1.21)	0.88 (0.59)	−9.60 (26.09)	−10.41 (34.91)	−34.00 (117.00)	−62.50 (101.75)
3 M FU	−78.35 (108.73)	−49.76 (68.90)	2.13 (1.48)	1.86 (1.32)	−31.20 (46.70)	−20.67 (53.27)	−115.50 (186.75)	− 97.00 (119.25)
6 M FU	−85.63 (96.73)	−63.22 (62.42)	3.07 (1.47)	2.94 (1.56)	−38.59 (53.98)	−56.20 (67.97)	−153.00 (202.50)	−132.50 (181.25)
P value	> 0.05		> 0.05		> 0.05		> 0.05	

*Displayed as median (quartile)

term follow-up. Also, clinical scales will be adopted to increase study objectivity.

CONCLUSIONS

The proposed microfocused ultrasound could effectively tighten the facial contour and improve soft tissue accumulation of the lower face in a single treatment. The device was highly safe with comparatively low pain and could be used effectively for facial tightening.

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Data Availability. The data that support the findings of this study are available from the corresponding author, Xiaoxi Lin, upon reasonable request.

Declarations

Conflict of Interest. Jiafang Zhu, Yue Han, Ying Liu, Rui Chang, Wei Gao, Xia Gong, Yijia Zhu, Ying Shang, Lingyue Shen, Wenxin Yu, Dongze Lyu, Xiaoxi Lin have nothing to disclose.

Ethical Approval. 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 Declaration of Helsinki and laboratory guidelines of research in China.

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