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ORIGINAL CONTRIBUTION

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Efficacy of high-intensity focused ultrasound in facial and neck rejuvenation

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Abstract

Background: High-intensity focused ultrasound (HIFU) has recently been introduced in the treatment of facial wrinkles and laxity.

Objective: The purpose of the study was to evaluate efficacy and safety of HIFU in facial and neck rejuvenation.

Methods: High-intensity focused ultrasound treatment was performed on face and neck by using two different probes with focal depth of 3 mm and 4.5 mm. Two independent, blinded clinicians evaluated the clinical improvement at 3 months after treatment. The patients also scored their satisfaction with the treatment. Adverse effects were assessed up to 3 months post-treatment.

Results: Seventy-five patients (73 female, 2 male) with Fitzpatrick skin phototypes 2-4 were enrolled in the study. After treatment, improvement in nasolabial, jawline, submental, and neck areas was separately evaluated. The rate of improvement in each area was more than 80% according to the physicians' assessment, while patients' satisfaction degree in each area was over 78%. Most common adverse effect was pain, reported in 25.3% of the patients during the procedure while transient erythema was reported in 6.7%. Both resolved spontaneously after the procedure. Only one patient complained development of numbness on right mandibular region which resolved spontaneously within 10 days.

Conclusion: High-intensity focused ultrasound can be an effective noninvasive treatment modality in facial and neck rejuvenation with an acceptable safety profile.

KEYWORDS

antiaging, high-intensity focused ultrasound, skin laxity, wrinkles

1 | INTRODUCTION

There is an increasing demand for the treatment of age-related facial skin changes, such as wrinkles and loss of elasticity. In response, various treatment modalities, including chemical peeling, microdermabrasion, fractional laser, and radiofrequency have been introduced.[1-4] Recently, high-intensity focused ultrasound (HIFU) has been developed for the treatment of facial wrinkles and laxity.[5]

High-intensity focused ultrasound is based on inducing cellular damage and volume reduction in the selected target area. The noninvasive delivery of focused ultrasound energy to the skin causes microcoagulation zones from the deep dermis to the superficial musculoaponeurotic system (SMAS) resulting in gradual tightening of the skin through collagen contraction and remodeling.[5] In this study, we evaluated clinical improvement, adverse effects, and patient satisfaction following HIFU treatment.

2 | MATERIALS AND METHODS

The study protocol was approved by the Institutional Review Board of the local ethics committee, and all subjects provided written-informed consent.

A single-center retrospective study between the years 2014-2017 was performed. Seventy-five patients treated by a single physician for the complaints concerning wrinkles with HIFU and followed up for 3 months were enrolled in this study. Data were collected from patient charts, and phone calls were placed to patients when additional information was required.

Exclusion criteria were as follows: current skin infection or inflammation, a history of keloid formation or connective tissue disease, severe systemic diseases (eg, uncontrolled liver disease or diabetes), a history of allergies, psychiatric disease, and participation in anti-aging procedures including lifting or laser treatment on the neck or chest within the past 12 months. At baseline, the Glogau photoaging classification scale was used to assess the clinical photodamage of the aging face. It is a four-point scale, classified as follows: type I-No wrinkles; type II-Wrinkles in motion; type III-Wrinkles at rest; type IV-Only wrinkles.[6]

High-intensity focused ultrasound was performed by a single physician, who followed up the patients 90 days following treatment. The procedure was performed on the face and neck area without the need of any topical anesthesia. After cleaning the treatment area, a layer of ultrasound gel was applied to the skin. For this study, we used a HIFU (Doublo-S; Hironic Co., Ltd.) machine with two different transducers, one with a focal depth of 4.5 mm and a frequency of 4 MHz (1.2 J), and another with a focal depth of 3 mm and a frequency of 7 MHz (0.3 J). Approximately 400-500 shots were delivered according to the size of the treated area.

TABLE 1 Descriptive data of the patients

Age (y)	
Min-Max (Median)	37-75 (51)
	53.01 ± 8.56
	n (%)
Gender	
Female	73 (97.3%)
Male	2 (2.7%)
Glogau type	
Type II	35 (46.7%)
Type III	35 (46.7%)
Type IV	5 (6.7%)
Adverse events	
None	48 (64..0%)
Present	27 (36.0%)
Pain	19 (70.4%)
Transient erythema	5 (18.5%)
Transient erythema and pain	2 (7.4%)
Numbness in the mandibular area	1 (3.7%)

Standardized photographs of the front of the face and profiles from each side were obtained at baseline/before treatment and 90 days after the treatment (by Canon EOS 60D camera). Improvement in three zones of the face, including nasolabial, submental and jawline, and the neck were evaluated.

Standardized photographs from the baseline and three-month follow-up were compared by two blinded dermatologists who were not directly involved in the treatments. Improvement in facial wrinkles was assessed using a 4-point scale: 0-no improvement; 1-mild improvement; 2-mild/moderate improvement; 3-moderate

FIGURE 1 Representative photographs taken before and 3 mo after treatment

improvement; 4-excellent improvement. In addition, each patient scored their satisfaction 3 months after treatment for each area of their face on a scale of 1 to 4 as follows: 1-not satisfied; 2-somewhat satisfied; 3-satisfied; 4-very satisfied. Any adverse effects were recorded up to 3 months post-treatment.

2.1 | Statistical analyses

The Number Cruncher Statistical System 2007 (NCSS) program was used for statistical analysis. The descriptive data were expressed with mean ± standard deviation, numeric variables, and percentages. Krippendorff's Alpha was used in the analysis of the consistence between the two reviewers and for each reviewer. The values used for Krippendorff's Alpha (*K*) were as follows: <0 = poor agreement; 0-0.20 = slight; 0.21-0.40 = fair; 0.41-0.60 = moderate; 0.61-0.80 = substantial; 0.81-1.00 = near perfect. The correlation analysis was performed using Spearman's rank correlation, and $P < 0.05$ was considered statistically significant.

3 | RESULTS

3.1 | Demographic information

Seventy-five patients (73 female, 97.3%; 2 male, 2.7%) were enrolled in the study. The mean age of the subjects was 53.01 ± 8.56 years, ranging from 37 to 75. Fitzpatrick skin types 2-4 were represented in our study. At the time of administration, the Glogau types of the patients were as follows: 35 patients (46.7%) had Glogau type 2, 35 patients (46.7%) had Glogau type 3, and 5 patients (6.7%) had Glogau type 4. All patients received one session of HIFU. Descriptive data from the subjects were shown in Table 1.

3.2 | Physicians' evaluation score

All patients showed clinical improvement in all areas after treatment compared with the baseline. The improvement was significant 3 months after treatment, and representative photos are shown in Figure 1. Two blinded independent dermatologists evaluated the patients as showing clinical improvement 3 months after treatment using a scale from 0 to 4, shown in Table 2. Qualitative assessment comparisons0 by the different reviewers were minimally different. Improvement degree in each area evaluated by Physician 1 and 2 are shown in Table 2 and 3.

3.3 | Patient satisfaction scores

In the surveys of patient satisfaction by area, the scores at 3 months were 2 (somewhat satisfied) or higher, shown in Table 3.

In the nasolabial region, 33 (44%) of the patients were satisfied and 26 (34.7%) were very satisfied. Forty-six (61.3%) patients were satisfied with the results in their jawline, and 19 (25.3%) of the patients were very satisfied. For submentum treatment, 39 (52%) patients were satisfied with the results and 22 (29.3%) were very satisfied. In the neck region, 40 (53.3%) patients were satisfied, while 21 (28%) were very satisfied.

3.4 | Association between the physicians, patient satisfaction, and physician evaluations

Relationship between the scores for the degree of improvement according to the physicians and patient satisfaction are summarized in Table 4.

Qualitative assessment comparisons by the two reviewers were minimally different. In the assessment of nasolabial, jawline, submental, and neck improvement, there was a statistically significant correlation between the scores of Physician 1 and 2 with an agreement of 76.4%, 60.3%, 68.4%, 70.35, respectively ($P = 0.001$, $P = 0.001$, $P = 0.001$, $P = 0.001$; respectively).

There was also a positive correlation between Physician 1 and patients' assessments and also between Physician 2 and patients' assessments in results of nasolabial, jawline, submental and neck areas ($P = 0.001$, $P = 0.001$; $P = 0.001$, $P = 0.001$; $P = 0.001$, $P = 0.001$; $P = 0.001$, $P = 0.001$; respectively).

Overall evaluation of the improvement in wrinkles between Physician 1 and 2 showed 68.6% correlation between scores. Physician 1 and the patients' assessments were correlated in 55.7%, and Physician 2 and the patients' assessments were 56.7%.

3.5 | Association between patient characteristics and clinical improvement

No correlation was found between the clinical improvement in each area and the ages of the patients (all, $P > 0.005$). Neither the physicians' and patients' scores for improvement in each area was not associated with Glogau types of the patients (all, $P > 0.005$).

TABLE 2 Improvement degree in each area evaluated by Physician 1 and 2

Treated area	excellent improvement n (%)		moderate improvement n (%)		mild/moderate improvement n (%)		mild improvement n (%)		no improvement n (%)	
	P1	P2	P1	P2	P1	P2	P1	P2	P1	P2
Nasolabial	14 (18.7%)	17 (22.7%)	56 (74.7%)	52 (69.3%)	5 (6.66%)	6 (8%)	0	0	0	0
Jawline	16 (21.3%)	17 (22.7%)	55 (73.3%)	55 (73.3%)	4 (5.33%)	3 (4%)	0	0	0	0
Submental	17 (22.7%)	14 (18.7%)	53 (70.7%)	57 (76%)	5 (6.66%)	4 (5.33%)	0	0	0	0
Neck	17 (22.7%)	20 (26.7%)	50 (66.7%)	40 (64%)	8 (10.67%)	15 (20%)	0	0	0	0

TABLE 3 The scores for each area evaluated by Physician 1, Physician 2, and patients' satisfaction scores

Treated area	Physician 1 mean ± SD (Min-max)	Physician 2 mean ± SD (Min-max)	Patients mean ± SD (Min-max)
Nasolabial	3.12 ± 0.49 (2-4)	3.14 ± 0.53 (2-4)	3.13 ± 0.74 (2-4)
Jawline	3.16 ± 0.49 (2-4)	3.18 ± 0.48 (2-4)	3.12 ± 0.61 (2-4)
Submental	3.16 ± 0.52 (2-4)	3.13 ± 0.47 (2-4)	3.1 ± 0.68 (2-4)
Neck	3.12 ± 0.56 (2-4)	3.17 ± 0.57 (2-4)	3.09 ± 0.68 (2-4)

3.6 | Adverse effects

Nineteen patients (25.3%) reported pain, five patients (6.7%) had transient erythema and two patients (2.7%) had both transient erythema and pain; all adverse effects were resolved after the procedure.

Only one patient (1.3%) had the complaint of numbness in the right mandibular region that resolved spontaneously within 10 days (Table 1).

4 | DISCUSSION

The aim of the present study was to evaluate the efficacy and safety of HIFU and compare the scores of patients and physicians in relation to clinical improvement. In the present study, a significant improvement was noted in each treated area by both physicians and the patients with minimal side effects.

Several treatment modalities have been developed in cosmetic and aesthetic dermatology through understanding the biology of the aging process. High-intensity focused ultrasound treatment has recently been introduced as an effective method for the improvement of wrinkles and skin laxity.[7-9] The procedure works by creating small micro-thermal lesions in the mid-to-deep reticular dermis up to the fibro-muscular layer, which causes the thermally induced contraction of collagen and tissue coagulation with subsequent neo-collagenesis without affecting the dermis the epidermis.[8-10] Focused ultrasound is superior to other pre-existing skin tightening technologies because of its capability to reach deeper tissues.[11]

Several studies have demonstrated the efficacy and safety of HIFU in facial skin tightening.[7] Suh et al[8] reported clinical and histopathologic improvements in facial skin of 28 patients after three sessions of HIFU treatment. Park et al[12] also reported HIFU as an effective and safe method in the treatment of facial wrinkles in the prospective study including 20 patients. They evaluated the efficacy of HIFU by dividing the face into seven areas, and they reported that physician evaluations and patient satisfaction with the clinical effects of HIFU were similar in all areas. Moreover, patient satisfaction was found to be higher than the evaluation by clinicians. They suggested that this difference may be due to the effects of HIFU on skin tone, facial contour, tightness of the skin, facial lifting, and the improvement of wrinkles.[12] Fabi et al[13] also conducted a retrospective study involving 48 subjects treated with one session of HIFU. They demonstrated significant lifting and tightening of facial and neck skin up to 180 days after treatment.[13] In another prospective study, two physicians judged 8 of 10 patients showing clinical improvement at variable degrees, while 9 of 10 patients assessed the treatment as efficient at different degrees.[14] In a prospective clinical study evaluating the efficacy of HIFU for rejuvenation of the lower face among 93 patients, improvements were reported by two-thirds of patients and by nearly 60% of blinded reviewers at day 90.[15]

In previous studies, clinicians have reported a clinical improvement in wrinkles ranging from 58.1% to 91% as a result of HIFU

TABLE 4 The relationship between evaluation of improvement by Physicians and Patients in each area

Improvement in	Physician 1-Physician 2	Physician 1-Patient	Physician 2-Patient
Nasolabial area			
r	0.764	0.605	0.595
P	*0.001***	*0.001***	*0.001***
Neck area			
r	0.703	0.605	0.651
P	*0.001***	*0.001***	*0.001***
Jawline			
r	0.603	0.475	0.517
P	*0.001***	*0.001***	*0.001***
Submental area			
r	0.674	0.606	0.562
P	*0.001***	*0.001***	*0.001***

Note: *r* = Spearman's correlation coefficient.
***P* < 0.01 (in italics).

treatment.[8,13-15] In the present study evaluating the efficacy of HIFU in 75 patients, clinical improvement results for HIFU treatment in the nasolabial, jawline, submental and neck areas, as evaluated by Physician 1 and 2 were excellent in at least 18.7% of cases with the best results in neck area. And at least 66% of the cases showed moderate improvement. More than 78% of the patients were satisfied or very satisfied with the results with the highest scores (86.7%) in jawline outcomes. These results were similar to findings in previous studies, in which patient satisfaction ranged from 65.6% to 90%.[8,13-15] In our study both physicians' and the patients' evaluation of the efficacy of HIFU treatment are in line with the literature. Furthermore, the large sample size of our study, compared with the previous reports, gives strength to our findings.

The most common complications related to HIFU include erythema, edema, and pain, all of which subside within days without treatment.[7] Additionally, whitish wheals/striations, bruising, postinflammatory hyperpigmentation,[9] paresthesia,[16] and (less commonly) fat atrophy[17] were noted. In our study, the most common adverse effect was also pain followed by transient erythema. Both resolve spontaneously, consistent with the literature.

Neurologic complications due to HIFU have been rarely described. Chan et al[9] reported one patient with mild numbness around the perioral region at 7 days post-treatment that resolved spontaneously within a month. Suh et al[8] reported 4 of 22 patients developing temporary numbness along the mandible that resolved 2-3 weeks later. One patient developed neuromuscular dysfunction after HIFU treatment, presenting with partial paralysis of the right perioral area. It resolved without special treatment within 2 months.[18] Along with the literature, in our study, one patient developed numbness on the right mandibular region after HIFU treatment that resolved spontaneously within 10 days. Although the exact mechanism of nerve injury after HIFU treatment is unknown, shrinkage and retraction at SMAS that is caused by the deep penetration of HIFU and the thermal energy may lead to the injury of nerve branches distributed in SMAS.[18] Since the marginal mandibular and temporal branches of facial nerve are located superficially on the face, especially on the locations innerved by these branches, the use of moderate energy settings may provide a safer treatment.

The study is limited by its retrospective design. Short follow-up period is also another limitation. In addition, the study lacks a histological analysis which would provide an objective assessment for estimating the degree and consistency of efficacy. However, we believe that the large sample size and the evaluation of three different areas of the face and neck distinguish our study from the previous studies.

In conclusion, HIFU treatment was found to be effective in the improvement of wrinkles in the facial and neck area. Patients who are not willing for surgical procedures or have contraindications for the surgery will benefit HIFU treatment. The present study demonstrated clinical improvement in the wrinkles in facial and neck areas and high patient satisfaction rates after only one session of HIFU treatment. Fast improvement after treatment and few side effects are also advantages of HIFU. The side effect profile of our study was similar to that of the literature, with minimal reactions. High-intensity focused ultrasound may be a safe, effective, and noninvasive option for improvement of wrinkles.

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