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ORIGINAL ARTICLE

Use of quantum molecular resonance energy for managing postrhinoseptoplasty perilesional edema and ecchymosis

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Abstract

Background: Quantum molecular resonance (QMR) technology employs nonionizing high-frequency waves ranging from 4 to 64 MHz to generate low-intensity quanta of energy that interacts with cellular components.

Aims: To evaluate the efficacy and safety of QMR treatment on postoperative perilesional edema and ecchymosis in patients with rhinoseptoplasty or revision rhinoseptoplasty.

Patients/Methods: In total, 30 patients were treated with QMR stimulation therapy (QMR group) once daily for 5 days, while another 30 patients were treated with conventional icepack application (control group). The duration of perilesional edema and ecchymosis were comparatively evaluated according to anatomic regions.

Results: In both groups, the longest duration of postoperative edema and ecchymosis was found on the left anterior cheek, followed by the right anterior cheek, left lower eyelid, right lower eyelid, and right and left upper eyelids. The mean duration of overall postoperative perilesional edema was significantly shorter in the QMR group (2.0 ± 0.8 days) than the control group (4.6 ± 2.0 days); the mean duration of overall ecchymosis was also markedly shorter in the QMR group (2.9 ± 1.5 days) than control group (7.5 ± 2.9 days). Patient satisfaction after postoperative QMR treatment was rated as 2.2 ± 0.8, whereas patient satisfaction in control group was rated as 1.6 ± 0.9.

Conclusion: Our clinical study demonstrated that postrhinoseptoplasty QMR treatment effectively reduces the duration of postoperative perilesional edema and ecchymosis without remarkable side effects. We suggest that QMR treatment can be considered as an alternative option for noninvasively managing postrhinoseptoplasty perilesional edema and ecchymosis.

KEYWORDS
ecchymosis, edema, quantum molecular resonance, rhinoseptoplasty

1 | INTRODUCTION

Quantum molecular resonance (QMR) technology emits nonionizing high-frequency (4–64 MHz) waves at low intensity to generate quanta of energy that can break molecular bonds without causing thermal damage in and around targeted tissue.[1,2] Meanwhile, research has shown that electromagnetic fields can regulate various cell functions, including cellular viability, proliferation, differentiation, and migration; inflammatory reactions; and gene expression profiles, by interacting with the cell membrane, which is composed

of charged molecules and proteins.[2-5] Further studies have indicated that manipulation of electromagnetic fields could theoretically be used to reduce inflammatory reactions and induce neovascularization and extracellular matrix production for promoting wound repair.[2,3] In support thereof, QMR technology has been used clinically in patients to treat painful inflammatory musculoskeletal disorders of various origins, chronic intractable ulcerative wounds in the extremities, and postoperative edema after total knee arthroplasty.[1,6]

Rhinoseptoplasty is a popular plastic surgical procedure of the face.[7-10] Revision rhinoseptoplasty is sometimes required in patients with a severely contracted nose resulting from excessive inflammatory reactions and fibrosis along nasal implants.[7,8] A severely contracted nose is a serious complication that often accompanies insufficient septal cartilage and disorganized, thick fibrotic skin, which complicates the performance of a rhinoseptoplasty.[7,8] To achieve maximal surgical outcomes and minimal downtime, many surgeons have adopted more minimally invasive procedures and stressed proper pre- and postoperative management.[9,10]

Perilesional edema and ecchymosis after rhinoseptoplasty and revision rhinoseptoplasty are distressing complications to both surgeons and patients.[9,10] As such, several methods have been suggested to decrease postrhinoseptoplasty edema and ecchymosis, including corticosteroid administration, intraoperative hypotension, and cooling to decrease bleeding from bony and soft-tissue trauma, postoperative head elevation, and postoperative hilotherapy.[10-13] In this retrospective cohort study, we aimed to evaluate the efficacy and safety of QMR stimulation therapy on postoperative perilesional edema and ecchymosis in patients undergoing rhinoseptoplasty or revision rhinoseptoplasty. Herein, QMR treatment was delivered to 30 patients from postoperative day 1 for 5 consecutive days, while another 30 patients were treated with conventional icepack application. Then, the durations of perilesional edema and ecchymosis were comparatively evaluated according to anatomic region.

2 | PATIENTS AND METHODS

2.1 | Patients

In this retrospective cohort study, we analyzed 60 Korean patients (27 males and 33 females; mean age: 32.5 ± 9.8 years; age range: 19–59 years), who had undergone a rhinoseptoplasty or revision rhinoseptoplasty between June 2020 and December 2020. Two groups of patients were included: 30 patients in the study group (13 males and 17 females; mean age: 31.9 ± 9.7 years; age range: 20–59 years) were treated with daily QMR stimulation therapy for 5 days (QMR group); the other 30 patients in the control group (14 males and 16 females; mean age: 33.1 ± 10.1 years; age range: 19–59 years) were treated with conventional icepack application daily for 5 days. Patients were excluded if they had hypertension, diabetes mellitus, peripheral artery disease, chronic liver disease, chronic renal disease, history of ischemic heart disease or stroke, a high risk of cardioembolism, history of hemorrhagic disease, predisposition to bleeding, blood clotting disorders, concurrent intake of anticoagulants, and concurrent smoking.

2.2 | Postoperative QMR stimulation therapy

After obtaining written informed consent, five sessions of QMR (Corage™; QuanteQ) treatment were delivered to 30 patients in the QMR group. The QMR device used in this study generated alternating current, high-, and constant-voltage, low-intensity QMR energy at high-frequencies of 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, and 64 MHz. The first session was performed on postoperative day 1 and was followed by another four sessions up to postoperative day 5. The skin along the face and upper neck was cleansed with 70% ethanol without pretreatment with topical anesthetic cream. Neutral emulsion (QuanteQ) was used as a coupling medium and was uniformly applied to the face and neck before QMR treatment (Figure 1A). The QMR stimulation therapy was delivered at the power of 30W for 20 min/session using a QMR applicator (SkinMono®; QuanteQ). The applicator was continuously moved on both cheeks, temples, forehead, and upper neck at 5 cm/s (Figure 1B-D). Neither posttreatment cooling nor prophylactic prescription of systemic or topical corticosteroids and antibiotics was utilized. In the control group, conventional icepacks were applied on the face and upper neck for 20 min each day for 5 days.

2.3 | Objective and subjective outcome assessment

Photographs were obtained using identical digital camera settings, lighting conditions, and patient positioning at every visit before performing QMR treatment or icepack application and at 7, 14, 21, and 28 days after operation. The photographs and medical records were analyzed for perilesional edema and ecchymosis by blinded investigators. Perilesional regions were divided into modified six regions (right and left upper eyelids, right and left lower eyelids, and right and left anterior cheeks).[13] During visits on postoperative day 28, patients scored their overall rates of satisfaction (0 = unsatisfied, 1 = slightly satisfied, 2 = satisfied, 3 = very satisfied) with postoperative down time, pain, perilesional edema, and ecchymosis. Moreover, our patients were asked to report any other side effects, including pain, transient erythema, oozing, itching, bleeding, bacterial folliculitis or furunculosis, viral or fungal infections, ulceration, prolonged erythema, dyspigmentation, and scarring, that occurred over the follow-up period.

2.4 | Statistical analysis

Values are presented as means ±standard deviations unless otherwise noted. The durations of perilesional edema and ecchymosis after rhinoseptoplasty or revision rhinoseptoplasty according to anatomic regions and patient satisfaction were analyzed using Prism 8.0

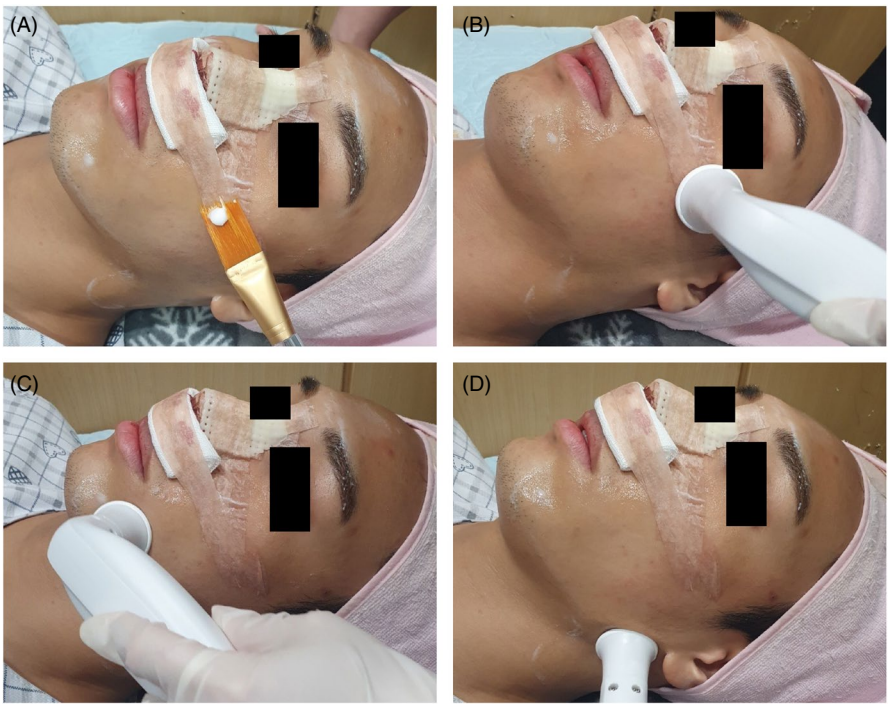

FIGURE 1 Postrhinoseptoplasty quantum molecular resonance (QMR) treatment. (A) Neutral emulsion was uniformly applied to the face and neck after cleansing with 70% ethanol before QMR treatment. (B–D) The QMR stimulation therapy was delivered at a power of 30 W for 20 min/session by continuously moving a QMR applicator along the face and upper neck at 5 cm/s

TABLE 1 Mean durations of postrhinoseptoplasty perilesional edema and ecchymosis at six anatomical regions in the control and quantum molecular resonance (QMR) groups

	Duration of edema (days)			Duration of ecchymosis (days)		
	Control[a]	QMR[a]	*p* value	Control[a]	QMR[a]	*p* value
Left upper eyelid	2.5 ± 0.9	1.2 ± 0.4	<0.0001	4.5 ± 1.3	1.2 ± 0.6	<0.0001
Right upper eyelid	2.5 ± 0.9	1.2 ± 0.4	<0.0001	4.5 ± 1.3	1.2 ± 0.6	<0.0001
Left lower eyelid	5.4 ± 1.2	2.2 ± 0.7	<0.0001	8.5 ± 1.9	3.5 ± 1.1	<0.0001
Right lower eyelid	5.1 ± 1.2	2.2 ± 0.5	<0.0001	8.0 ± 2.2	3.5 ± 1.0	<0.0001
Left anterior cheek	6.1 ± 1.5	2.6 ± 0.7	<0.0001	9.9 ± 2.3	4.0 ± 1.0	<0.0001
Right anterior cheek	5.9 ± 1.7	2.6 ± 0.7	<0.0001	9.5 ± 2.4	3.9 ± 1.0	<0.0001

[a]Values were presented as mean ±standard deviation.

(GraphPad Software). A normality test was performed for data using the Kolmogorov-Smirnov test. Results were analyzed using Student's t-test and Tukey's and Sidak's multiple comparison tests for intra-group and intergroup comparisons, respectively. Differences with *p* values of less than 0.05 were considered statistically significant.

3 | RESULTS

3.1 | Baseline characteristics

Among the 30 patients in the QMR group, 23 (76.7%) patients underwent a rhinoseptoplasty, and 7 (23.3%) patients underwent revision rhinoseptoplasty. Among the 30 patients in the control group, 26 (86.7%) patients underwent a rhinoseptoplasty, and 4 (13.3%) patients underwent revision rhinoseptoplasty ($p > 0.05$). During the surgeries, lateral osteotomies were performed using an external perforating method with a 2-mm straight osteotome at the end of the procedure in 16 (53.3%) patients in the QMR group and in 15 (50%) patients in the control group ($p > 0.05$). Differences in other baseline patient characteristics between the QMR and control groups, including sex and age, were statistically insignificant ($p > 0.05$). All of the patients were prophylactically administered with systemic second-generation cephalosporin for 2 days after surgery. None of the patients were treated with systemic corticosteroids.

3.2 | Intra-group comparison of postoperative perilesional edema and ecchymosis

In the control group, the longest duration of postoperative edema was found on the left anterior cheek, followed by the right anterior cheek, left lower eyelid, right lower eyelid, and right and left upper eyelids (Table 1, Figures 2, 3). The duration of edema on the left and right anterior cheek was significantly longer than that on other areas ($p < 0.0001$, respectively). The longest duration of postoperative ecchymosis was found on the left anterior cheek, followed by the right anterior cheek, left lower eyelid, right lower eyelid, and right and left

upper eyelids. The overall duration of ecchymosis on the left and right anterior cheek was significantly longer than that on other areas ($p < 0.0001$, respectively). The duration of ecchymosis on the left lower eyelid was longer than that on the left ($p = 0.0067$) and right ($p = 0.0002$) upper eyelids, and that on the right lower eyelid was longer than that on the right upper eyelid ($p = 0.0113$). Otherwise, no statistically significant differences in the durations of postoperative edema and ecchymosis were noted between the right and left sides of each anatomic region ($p > 0.05$, respectively).

In the QMR group, the longest duration of postoperative edema was found along the left anterior cheek, followed by the right anterior cheek, left lower eyelid, right lower eyelid, and right and left upper eyelids (Figures 4, 5). The duration of edema on the left and right anterior cheek was significantly longer than that on other areas ($p < 0.0001$, respectively). The longest duration of postoperative ecchymosis was found on the left anterior cheek, followed by the right anterior cheek, left lower eyelid, right lower eyelid, and right and left upper eyelids. The duration of ecchymosis on the left and right anterior cheek was significantly longer than that on other areas ($p < 0.0001$, respectively), and that on the left lower eyelid was longer than that on the left ($p = 0.0409$) and right ($p = 0.0044$) upper eyelids. Otherwise, no statistically significant differences in the durations of postoperative edema and ecchymosis were recorded between the right and left sides of each anatomical region ($p > 0.05$, respectively).

3.3 | Inter-group comparison of postoperative perilesional edema and ecchymosis

The mean duration of overall postoperative perilesional edema was shorter in the QMR group (2.0 ± 0.8 days) than the control group (4.6 ± 2.0 days) ($p < 0.0001$). The mean duration of overall ecchymosis was also shorter in the QMR group (2.9 ± 1.5 days) than in the control group (7.5 ± 2.9 days) ($p < 0.0001$). More specifically, the mean durations of edema on the left and right upper eyelids in the QMR group were shorter than those in the control group, respectively, and the mean durations of ecchymosis on the left and right upper eyelids in the QMR group were shorter than those in the control group (Table 1). The mean durations of edema on the left and right lower eyelids in the QMR group were shorter than those in the control group, respectively, and the mean durations of ecchymosis on the left and right lower eyelids in the QMR group were shorter than those in the control group. Additionally, the mean durations of edema on the left and right anterior cheeks in the QMR group were shorter than those in the control group, respectively, and the mean durations of ecchymosis on the left and right anterior cheeks in the QMR group were shorter than those in the control group.

3.4 | Patient satisfaction rate and adverse events

The overall patient satisfaction rate, which was subjectively scored by each patient by considering postoperative down time, pain, perilesional edema, and ecchymosis, was reported at postoperative 28 days. Patient satisfaction after postoperative QMR treatment was rated as 2.2 ± 0.8, whereas that in the control group was rated as 1.6 ± 0.9 ($p = 0.0039$). None of the patients in the QMR group reported remarkable side effects, including pain during and after the treatments, transient erythema, oozing, itching, bleeding, bacterial folliculitis or furunculosis, viral or fungal infections, ulceration, prolonged erythema, dyspigmentation, or scarring, over the follow-up period.

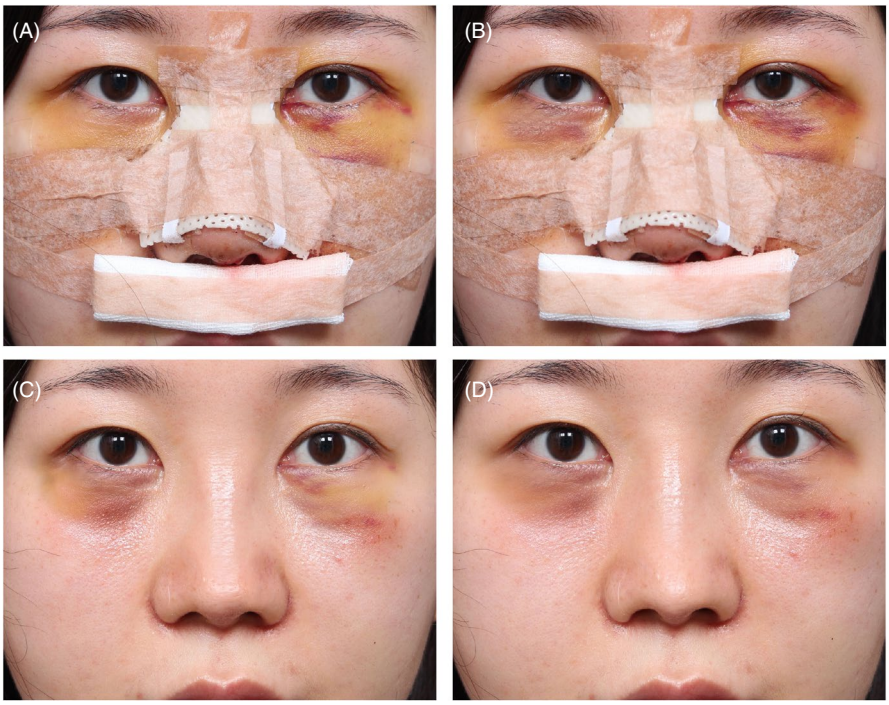

FIGURE 2 Photographs of a 27-year-old female patient in the control group. Photographs were taken under normal light exposure at (A) 1, (B) 4, (C) 7, and (D) 14 days after first revision rhinoseptoplasty with bilateral osteotomy

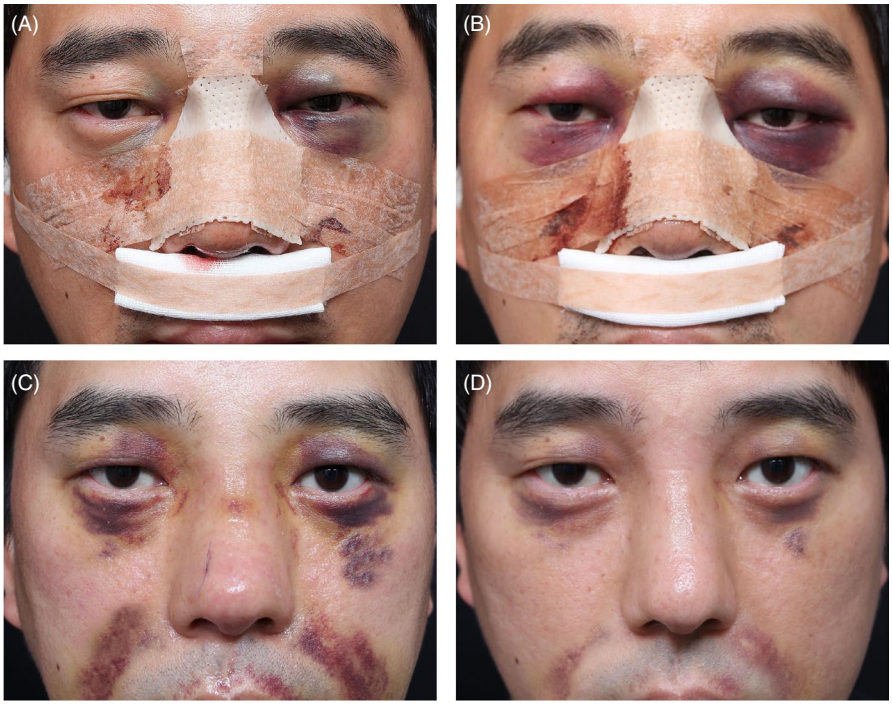

FIGURE 3 Photographs of a 42-year-old male patient in the control group. Photographs were taken under normal light exposure at (A) 1, (B) 4, (C) 7, and (D) 14 days after a rhinoseptoplasty with unilateral (left) osteotomy

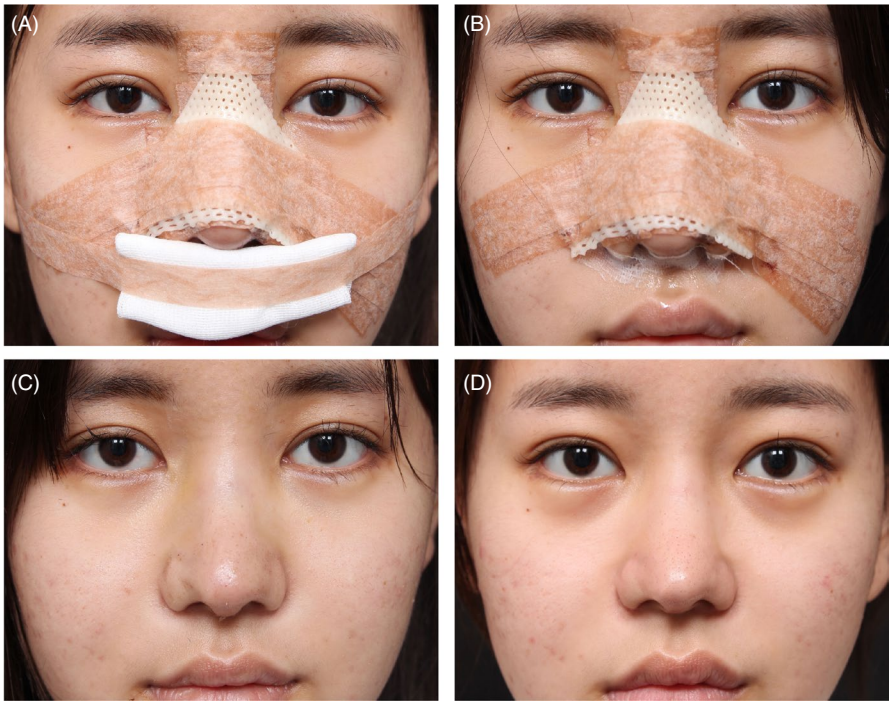

FIGURE 4 Photographs of a 20-year-old female patient in the QMR group. Photographs were taken under normal light exposure at (A) 1, (B) 4, (C) 7, and (D) 14 days after a second revision rhinoseptoplasty with autologous costal cartilage graft

4 | DISCUSSION

In this study, 30 patients treated with five sessions (20 min/session) of QMR treatment post-rhinoseptoplasty at 1-day intervals experienced significantly reduced durations of postsurgery perilesional edema and ecchymosis, compared with 30 control patients treated conventionally with icepacks. Clinical advantages for QMR stimulation included the painless nature of the procedure during and after treatment and no downtime. Also, no preparation, except for application of a coupling medium, was required.

Pulsed electromagnetic field therapy has been shown to improve wound repair by enhancing cellular proliferation and decreasing inflammatory chemokine production.[1,4] Moreover, research has shown that extremely low-frequency electromagnetic fields stimulate endothelial cells to produce vascular endothelial growth factor (VEGF) receptor-2 and induce angiogenesis.[14] Additional effects of pulsed electromagnetic fields therapy include increased extracellular matrix deposition, decreased inflammatory responses, increased DNA and protein synthesis, regulation of insulin-like growth factor and tumor growth factor receptors, and antibacterial activity.[1] QMR

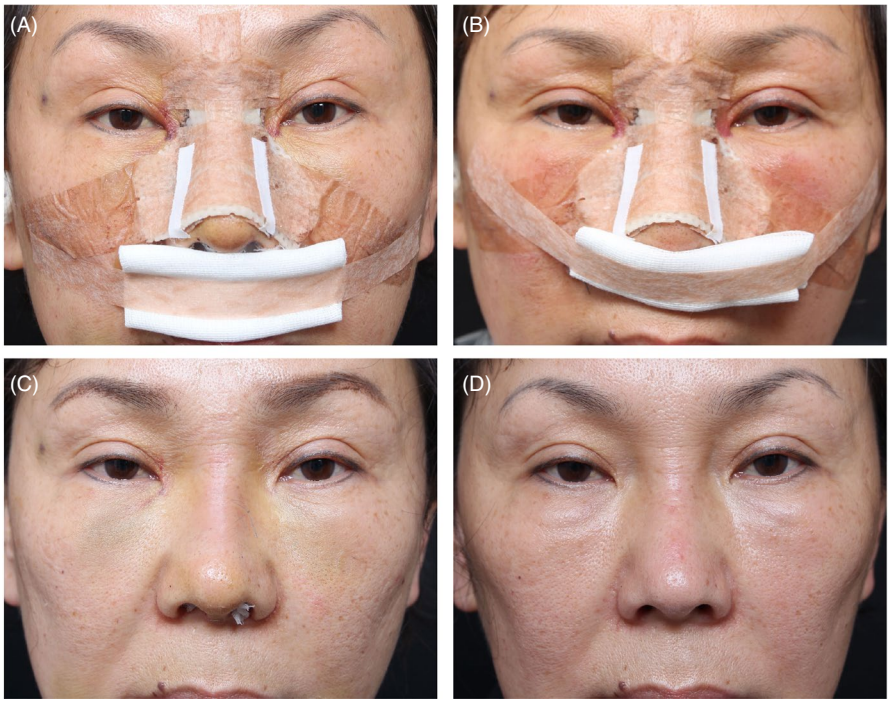

FIGURE 5 Photographs of a 56-year-old female patient in QMR group. Photographs were taken under normal light exposure at (A) 1, (B) 4, (C) 7, and (D) 14 days after a second revision rhinoseptoplasty

technology was developed based on the effects of pulsed electromagnetic fields therapy[1] and has been already applied for various medical and surgical purposes.[2]

Studies investigating the action mechanisms of QMR stimulation have highlighted effects on genes involved in the remodeling of extracellular matrix, angiogenesis, and cellular migration for wound repair and tissue development.[2,15,16] Microarray analysis has further suggested that post-QMR angiogenesis and tissue regeneration could result from remodeling of extracellular matrix.[2] One histopathologic analysis was performed in patients with intractable chronic wounds on the extremities after QMR treatment,[1] wherein post-QMR skin specimens exhibited remarkable decreases in inflammatory cells, upregulated VEFG expression, and decreased matrix metalloproteinase expression, along with clinical improvement in the chronic wounds and significant reductions in wound-related pain.[1]

In this study, all of our patients experienced shorter durations of postoperative edema and ecchymosis along the upper eyelids, followed by the lower eyelids and anterior cheeks, regardless of treatment group. Accordingly, the resolution of postoperative edema and ecchymosis seems to be topographically associated with the lymphatic drainage system at the face and neck. Our patients in both groups showed significantly longer durations of edema and ecchymosis on the left anterior cheek. The reason thereof is likely that the most of the lateral osteotomies were performed unilaterally on the left side.

A previous in vivo human histopathologic study revealed that post-QMR specimens show decreased inflammatory cell infiltration, down-regulation of metalloproteinase expression, and up-regulation of VEGF expression.[1] Additionally, research has shown that treatments employing extremely low electromagnetic fields can reduce the production of proinflammatory mediators and enhance the growth rate of keratinocytes that promote wound repair.[4] Moreover, one study has indicated that induction of lymphatic vasculature is correlated with the reduced severity of inflammatory reactions.[17] We suggest that the observed improvements in the durations of postoperative edema and ecchymosis in our patients may be associated with increased angiogenesis and lymphangiogenesis and with inhibition of inflammatory reactions promoted by QMR-induced wound repair.

In conclusion, our clinical study demonstrated that postrhinoseptoplasty QMR treatment effectively reduces durations of postoperative perilesional edema and ecchymosis without remarkable side effects. The postoperative management of perilesional edema and ecchymosis was associated with reduced down time and greater patient satisfaction. Therefore, QMR stimulation can be considered as an alternative, noninvasive modality for effectively managing perilesional edema and ecchymosis postrhinoseptoplasty. Further randomized controlled split-face clinical studies should be followed to confirm our findings, however.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

Hyoung-Moon Kim, Wook Oh, Do Yeon Kim, and Tae Hwan Ahn involved in conceptualization and resources. Hyoung-Moon Kim, Wook

Oh, and Tae Hwan Ahn involved in data curation. Hyoung-Moon Kim, Do Yeon Kim, and Tae Hwan Ahn involved in formal analysis, supervision, and visualization. Hyoung-Moon Kim and Do Yeon Kim involved in investigation. Hyoung-Moon Kim and Wook Oh involved in methodology. Hyoung-Moon Kim and Tae Hwan Ahn involved in project administration and validation. Hyoung-Moon Kim and Tae Hwan Ahn wrote original draft. Hyoung-Moon Kim, Wook Oh, Do Yeon Kim, and Tae Hwan Ahn wrote, reviewed, and edited the manuscript.

ETHICAL APPROVAL

The study was conducted in accordance with the Declaration of Helsinki. Approval to conduct the study was granted by the Institutional Review Board of the Korea National Institute for Bioethics Policy (KoNIBP).

DATA AVAILABILITY STATEMENT

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

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