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Clinical Effects of Far-Infrared Therapy in Patients with Allergic Rhinitis

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Abstract—**Allergic rhinitis (AR) is the sixth most common chronic illness worldwide, which has a significant impact on patients' quality of life. The actual cost of AR is staggering, approximately $5.6 billion being spent annually in direct medical costs and other indirect costs. Therefore, it should be taken seriously upon its evaluation and treatment. AR is an IgE-mediated inflammation, which symptoms are likely due to increased vascular permeability. Current therapeutic options such as avoidance of allergen, medication and immunotherapy are unsatisfactory. Far-infrared (FIR) is an invisible electromagnetic wave with a wavelength longer than that of visible light. It has been used to treat vascular diseases as a result of an increase in blood flow. The objective of this study was to evaluate the clinical effects of FIR therapy in patients with AR. Thirty-one patients with AR were enrolled in this study. A WS TY101 FIR emitter was placed to face the patient's nasal region at a distance of 30 cm. The treatment was performed for 40 min every morning for 7 days. Every day, patients recorded their symptoms in a diary before and during treatment. Each symptom of rhinitis was rated on a 4-point scale (0-3) according to severity. During the period of FIR therapy, the symptoms of eye itching, nasal itching, nasal stuffiness, rhinorrhea and sneezing were all significantly improved. Smell impairment was not improved until after the last treatment. No obvious adverse effect was observed in the patients during treatment and follow-up. We concluded that FIR therapy could improve the symptoms of AR and might serve as a novel treatment modality for AR.**

I. Introduction

ALLERGIC rhinitis (AR) is a global health issue affecting 15% to 30% of the world's population, with increasing prevalence over the last decade [1],[2]. The clinical symptoms of the nasal allergic response include nasal itching, rhinorrhea, nasal congestion, eye itching, etc. [3]. It not only alters the self-perceived health status, pose limitations in everyday activities, but also affect the working and school productivity [4],[5]. Allergic rhinitis obviously interferes with the quality of life and has become progressively clear that it is a common comorbid condition with asthma, allergic conjunctivitis, sinusitis, otitis media, nasal polyposis and respiratory infections [6]-[9]. Although AR is not associated with severe morbidity and mortality, it nevertheless exerts a significant economic burden on society compared with other chronic conditions.

The management of allergic rhinitis includes avoidance of the allergen, medication (pharmacological treatment) and allergen immunotherapy. It is no doubt that effective allergen avoidance can lead to substantial relief of symptoms. However, patients are still not able to avoid their confirmed allergens such as mites or atmospheric pollens under many circumstances. Well-established pharmacological therapies with oral and topical H1-antihistamines, topical and systemic glucocorticosteroids, hormones, decongestants and anti-leukotrienes are available for the treatment of the disease. According to the guidelines, oral antihistamines are the first-line therapy [10]-[12]. Intranasal steroids are recommended as first-line treatment in moderate and severe disease, and have been used traditionally to combat nasal congestion, along with the other symptoms associated with allergic rhinitis [13]. Although most of the drugs are effective in treating certain symptoms of AR, they all have limitations due to their adverse effects. Rather than simply to treat the symptoms, immunotherapy has the potential to provide a permanent cure for the disease. However, the technique is burdensome; requiring a lengthy series of injection, and it may not applicable to all patients [14]. Safety concerns about current treatments pose an important restriction on their use. Therefore, it is necessary to develop an improved treatment options for this disease.

Far-infrared (FIR) is an invisible electromagnetic wave with a longer wavelength than that of visible light. It is part of infrared radiation, which is subdivided into three categories according to different wavelengths: near (0.8-1.5 μm), middle (1.5-5.6 μm) and far-infrared (5.6-1000 μm) radiation. FIR has been reported to inhibit tumor growth in mice and was used to treat some vascular-related disorders [15]-[17]. Recent studies also demonstrated that FIR may increase blood flow [18], leading to the use of improving access flow and potency of the arteriovenous fistula in hemodialysis patients [19]. However, there is no report of using FIR to treat patients with AR, which symptoms are likely due to increased vascular permeability. The aim of this study was to evaluate the clinical effects of far-infrared therapy in patients with allergic rhinitis.

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II. Materials and Methods

A. Patients

Thirty-one patients with perennial allergic rhinitis were enrolled in our study. Patients ages ranged from 5 to 56 years (mean 25.3 years) and the male: female ratio was 18: 13. All patients had daily symptoms despite antihistamines and local steroid spray treatments. Patients with severe deviation of the nasal septum causing bilateral nasal obstruction were excluded from the study. Candidates in whom fibroscopy revealed purulent postnasal drip flowing from an edematous and hyperemic infundibulum or with streaks of purulent discharge flowing across the eustachian tube orifice were diagnosed as suffering from sinusitis and were excluded from the study. Also excluded were patients who were convalescing from an upper respiratory tract infection or had used nasal or oral corticosteroids less than 30 days before the start of the study.

After recording their symptoms in a diary for 1 week, all candidates for inclusion in the study underwent videoendoscopic examination of the nose. Each patient was examined by the use of a rigid endoscope introduced as deeply as possible into the nostril for close examination of the mucosa and intranasal structures. In addition, a flexible endoscope was used to penetrate the narrow intranasal passages not accessible by the rigid endoscope, thus enabling close examination of the nasal cavity. The study was reviewed and approved by Medical Ethics and Human Trial Committee of Tao-Yuan General Hospital, Tao-Yuan, Taiwan, ROC. All patients gave written, informed consent before treatment.

B. Diagnosis of AR

The diagnosis of allergic rhinitis was based on definite symptoms of nasal itching, rhinorrhea, sneezing, nasal obstruction or mouth breathing, as well as positive reactions to blood tests to antigens, such as house dust mite, cockroach, molds, feathers, grass pollen, weed pollens, sage pollen, and local tree pollens, etc. Criteria for positive skin prick test responses were a wheel of 3 mm or greater diameter with erythema of at least 5 mm. Histamine control skin test was read at 10 minutes, allergen and negative control skin tests were read at 15 minutes.

C. Scoring of Symptoms

A symptom score of 0 to 3 was assigned for each of the following rhinitis symptoms: eye itching, nasal itching, nasal stuffiness, rhinorrhea, smell impairment and sneezing. The patients scored the severity of their symptoms on a four-point scale once a day in a diary; 0 = no symptom, 1 = mild, 2 = moderate and 3 = severe symptom (Table 1). All adverse effects observed during the treatment were recorded.

D. FIR Therapy

A WS TY101 FIR emitter (WS Far Infrared Medical Technology Co., Ltd., Taipei, Taiwan, ROC) was used for FIR therapy in this study. The wavelength of the light generated from the electrified ceramic plates of this emitter was in the range between 5 and 12 μm with a peak at 8.2 μm. The radiator was positioned to face to a patient's nasal region at a distance of 30 cm. The therapeutic time was 40 minutes everyday for 7 days. All the FIR therapies were performed in the morning during 9 am to 12 pm. During the course of the study, the patients did not receive any other anti-allergic management.

TABLE I
SCORING OF SYMPTOMS

Scoring of eye itching
0: no eye itching
1: rubbing eyes less than 5 episodes a day
2: rubbing eyes 6-10 episodes a day
3: rubbing eyes more than 10 episodes a day
Scoring of nasal itching
0: no nasal itching
1: rubbing nose less than 5 episodes a day
2: rubbing nose 6-10 episodes a day
3: rubbing nose more than 10 episodes a day
Scoring of nasal stuffiness
0: no nasal stuffiness
1: nasal stuffiness without mouth breathing
2: nasal stuffiness with sporadic mouth breathing
3: nasal stuffiness with predominant mouth breathing
Scoring of rhinorrhea
0: no nasal blowing
1: nasal blowing less than 5 episodes a day
2: nasal blowing 6-10 episodes a day
3: nasal blowing more than 10 episodes a day
Scoring of smell impairment
0: no smell impairment
1: hyposmia with mild smell impairment
2: hyposmia with moderate smell impairment
3: anosmia
Scoring of sneezing
0: no sneezing
1: sneezing less than 5 episodes a day
2: sneezing 6-10 episodes a day
3: sneezing more than 10 episodes a day

E. Statistical Analysis

The effects of FIR on the clinical symptoms were analyzed by the paired samples t-test. We compared the mean symptom scores before (pre-therapy) and every time after (post-therapy) the patients completed FIR therapy. To the right of the paired differences, we saw the T, degrees of freedom, and significance. A p value of less than 0.05 was considered to be statistically significant.

III. Results

A. Effects of FIR in the Clinical Symptoms

Thirty-one patients enrolled in the study completed the FIR therapy. Mean values of daily registrations for eye itching, nasal itching, nasal stuffiness, rhinorrhea, smell impairment and sneezing are given in Figure 1. The most severe symptom

of the pre-treat patients was rhinorrhea, which the mean value of the symptom score was 2.26, followed by sneezing and nasal stuffiness with scores of 1.94 and 1.84, respectively. The least severe symptom of the pre-treat patients was smell impairment with a mean score of 0.61. After the one-week treatment period, significant improvements were observed in all the symptoms of AR patients (Table 2). The improved clinical symptoms were usually seen 1 day after the start of therapy, and thereafter the improvement was continuous. However, the smell impairment did not reveal significant improvement until after the 7th therapy. All the symptom scores were reduced by more than 50% at the end of the FIR therapy.

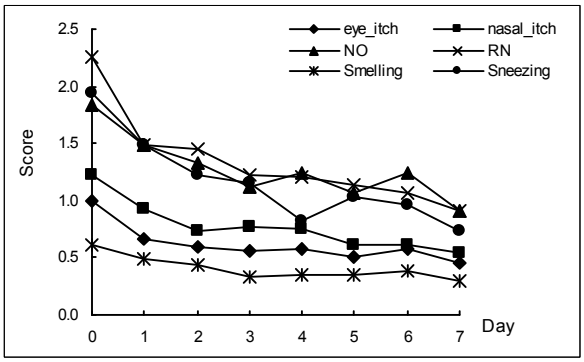

Fig. 1. Mean values of daily scores for six symptoms. The score is given on a scale from 0 = no symptom to 3 = severe symptom. The symptom scores decreased over the period of treatment. Pre-treatment (Day 0); during treatment (Day 1-7).

B. Side effects of FIR therapy

A 68-year-old male patient dropped out on the 2nd day because of insomnia after the first treatment. Mild flush occurred in two female patients, but they did not feel uncomfortable and had completed the therapy. The symptom disappeared within few days after the last treatment. The patients tolerated the treatment well, and no severe adverse effects were observed.

IV. Discussion

Our study demonstrated the improving effect of FIR therapy on the clinical symptoms of allergic rhinitis. Most of the clinical symptoms were quickly and significantly improved. However, the smell impairment did not improve until after the last treatment. This was probably because the pre-treatment score of smell impairment was only 0.61 and not much room for decreasing of the score or FIR was not so effective on improving olfactory disorder.

The symptoms of AR could be improved by FIR radiation, the definite mechanism remained unclear. Vaupel *et al*. found that the temperature increased up to 4°C in 10-mm depth of tissue [20]. FIR could penetrate through skin and gradually transfer energy as deep as 2 to 3 cm into subcutaneous tissue through a resonance-absorption mechanism of organic and water molecules without irritating or overheating the skin [17], [21]. Yu *et al*. reported that the temperature of skin steadily

TABLE II
ESTIMATED PRE-TREATMENT SEVERITY OF ALLERGIC RHINITIS AND THEIR IMPROVEMENT DURING FAR-INFRARED TREATMENT

Paired Samples t-Test		Mean of Paired Differences	*P* value
Pair 1	[1]eye_itch_0 - [2]eye_itch_1	0.33	0.0097
Pair 2	eye_itch_0 - eye_itch_2	0.41	0.0052
Pair 3	eye_itch_0 - eye_itch_3	0.44	0.0013
Pair 4	eye_itch_0 - eye_itch_4	0.39	0.0089
Pair 5	eye_itch_0 - eye_itch_5	0.46	0.0045
Pair 6	eye_itch_0 - eye_itch_6	0.39	0.0460
Pair 7	eye_itch_0 - eye_itch_7	0.55	0.0034
Pair 8	[3]N_O_0 - N_O_1	0.52	0.0133
Pair 9	N_O_0 - N_O_2	0.67	0.0002
Pair 10	N_O_0 - N_O_3	0.89	0.0000
Pair 11	N_O_0 - N_O_4	0.68	0.0001
Pair 12	N_O_0 - N_O_5	0.86	0.0000
Pair 13	N_O_0 - N_O_6	0.68	0.0007
Pair 14	N_O_0 - N_O_7	0.94	0.0000
Pair 15	[4]nasal_itch_0 - nasal_itch_1	0.37	0.0387
Pair 16	nasal_itch_0 - nasal_itch_2	0.56	0.0084
Pair 17	nasal_itch_0 - nasal_itch_3	0.52	0.0238
Pair 18	nasal_itch_0 - nasal_itch_4	0.54	0.0134
Pair 19	nasal_itch_0 - nasal_itch_5	0.68	0.0021
Pair 20	nasal_itch_0 - nasal_itch_6	0.68	0.0044
Pair 21	nasal_itch_0 - nasal_itch_7	0.68	0.0024
Pair 22	[5]RN_0 - RN_1	0.70	0.0020
Pair 23	RN_0 - RN_2	0.74	0.0004
Pair 24	RN_0 - RN_3	0.96	0.0000
Pair 25	RN_0 - RN_4	1.00	0.0000
Pair 26	RN_0 - RN_5	1.07	0.0002
Pair 27	RN_0 - RN_6	1.14	0.0002
Pair 28	RN_0 - RN_7	1.35	0.0000
Pair 29	[6]smelling_0 - smelling_1	0.11	0.4157
Pair 30	smelling_0 - smelling_2	0.15	0.2557
Pair 31	smelling_0 - smelling_3	0.26	0.0697
Pair 32	smelling_0 - smelling_4	0.21	0.1362
Pair 33	smelling_0 - smelling_5	0.21	0.1362
Pair 34	smelling_0 - smelling_6	0.18	0.2587
Pair 35	smelling_0 - smelling_7	0.32	0.0390
Pair 36	sneezing_0 - sneezing_1	0.52	0.0104
Pair 37	sneezing_0 - sneezing_2	0.78	0.0005
Pair 38	sneezing_0 - sneezing_3	0.85	0.0000
Pair 39	sneezing_0 - sneezing_4	1.14	0.0000
Pair 40	sneezing_0 - sneezing_5	0.93	0.0000
Pair 41	sneezing_0 - sneezing_6	1.00	0.0000
Pair 42	sneezing_0 - sneezing_7	1.19	0.0000

[1]eye_itch_0 = mean score of eye itching pre-treatment; [2]eye_itch_1 = mean score of eye itching after 1st treatment; [3]N_O = nasal stuffiness; [4]nasal_itch = nasal itching; [5]RN = rhinorrhea; [6]smelling = smell impairment

increased to a plateau between 38 and 39°C during the FIR therapy for 30 to 60 minutes, in which the distance between radiator and the skin was 20 cm [18]. The temperature of nasal cavity in some patients was measured before and during the treatment of FIR. The temperature of the nasal cavity was around 35°C before the treatment, and it progressively increased up to 37°C during the therapy. Thus, our study suggested FIR could be free of burn injury and might result in thermal effect in nasal mucosa. Yerushalmi *et a*l. used a series of three 30-min insufflations of humidified air at 43°C during 2-hr interval of treating the patients with perennial allergic rhinitis and demonstrated that local hyperthermia was effective to treat the disease [22]. Local hyperthermia applied to the nasal passages might enhance elements of the host's defense arsenal, increasing the host's defense against the conjugate factors leading to the symptoms of allergic rhinitis. Our results showed that the clinical symptoms were improved during the course of the therapy. Thermal effects might play a role in the mechanism of FIR therapy.

AR can be triggered by perennial or seasonal allergens, the most common of which are house dust, animal dander, mold spores, and pollen. An encounter with the allergen of sensitivity causes sneezing, nasal itch, rhinorrhea, and nasal stuffiness, resulting from afferent nerve stimulation, glandular hypersecretion, increased vascular permeability, and the infiltration of inflammatory cells. Nitric oxide (NO) was produced in higher concentrations by the nasal mucosa of untreated AR patients compared with normal individuals [23]. It arises from the reaction between L-arginine and NO synthases, which are expressed by endothelial cells, macrophages, neutrophils, mast cells, fibroblasts and by parasympathetic neurons. The evidence demonstrated that these substances mediate the immediate allergic response, and together they are considered to induce the characteristic sympromatology. Akasaki *et al*. reported that repeated FIR therapy could upregulate the expression of endothelial NO synthase (eNOS) [24]. Moreover, Yu *et al*. considered that FIR therapy promoted skin blood flow through a mechanism closely related to L-arginine/NO pathway. Therefore, in addition to the thermal effects, the improvement of nasal symptoms may result from nonthermal effects of FIR.

V. Conclusion

Our study demonstrated that FIR therapy could improve the clinical symptoms of patients with AR. FIR therapy may be a noninvasive and safe modality in the treatment of AR.

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