

Far-infrared treatment of experimental sinusitis in rabbits: a pilot study

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Abstract. – OBJECTIVE: Thermal therapy has existed for thousands of years and dates back to ancient civilizations such as the Finns, Romans, ancient Chinese, American Indians, and Egyptians. Sun therapy is a form of natural Far Infrared Rays (FIR) thermal therapy. Far infrared rays are invisible rays with the longest wavelength of natural sunlight. However, sunbathing should only be done in moderation, as sunlight contains ultraviolet rays that can burn and damage the skin. More than 30 million people in Asia, Europe, and Australia receive Far Infrared Therapy with FIR lamps. They emit 2–25-micron wavebands. We aimed to investigate whether FIR therapy that uses a similar waveband improves sinusitis symptoms.

MATERIALS AND METHODS: This study was conducted on 10 New Zealand rabbits of both sexes, 7-8 months old, with an average weight of 1.8-2.4 kg. They were divided into four study groups. Sinusitis was induced in rabbits by blocking the sinus ostium, whereas some were left as control. Far infrared treatment with an infra-sin device was given with or without antibiotics. Mucosal samples were evaluated microscopically regarding epithelial eruption, epithelial vacuolization, interstitial edema, vascular congestion, leukocyte infiltration, and mucosal thickening.

RESULTS: We found clinical and histopathological improvements in rabbits with sinusitis on the right side of the nose, to which we applied FIR treatment with the device Infra-Sin.

CONCLUSIONS: Our findings in this animal study led us to conclude that it would be beneficial to study the effects of FIR treatment on people with allergic rhinitis and sinusitis and to identify the optimal dosing, treatment duration, and intensity. To add to our findings, looking into whether FIR therapy can be used as an alternative to antibiotic treatment for human sinusitis is essential.

Key Words:

Far infrared radiation (FIR), Infrasin, Sinusitis, Far-infrared treatment, Thermal therapy, Rabbits with experimental sinusitis.

Introduction

Thermal therapy has existed for thousands of years and dates back to ancient civilizations such as the Finns, Romans, ancient Chinese, American Indians, and Egyptians. Since ancient times, people have known that exposure to sunlight can protect and improve health. Sun therapy is a form of natural Far Infrared Rays (FIR) thermal therapy. Far infrared rays are invisible rays with the longest wavelength of natural sunlight. However, sunbathing should only be done in moderation, as sunlight contains ultraviolet rays that can burn and damage the skin. More than 30 million people in Asia, Europe, and Australia receive far infrared therapy with FIR lamps to treat various problems. Far-infrared radiation (FIR) exerts numerous beneficial effects on health and cell physiology. Recent studies¹⁻⁴ revealed that the biological effects of fir are independent of thermal effects. While large-scale studies are needed to prove the benefits of far infrared therapy, there are many benefits from existing research. FIR increases blood circulation and expands capillaries. FIR thus removes fats, chemicals, and toxins from the blood. Researchers have reported⁵⁻⁸ that FIR helps remove toxins, such as heavy metals and carcinogens from food processing, lactic acid, free fatty acids and subcutaneous fats associated with aging and fatigue, excess sodium associated with blood pressure, and uric acid. It has been demonstrated in many studies⁵⁻⁸ that FIR reduces pain and muscle spasms in nerve endings, causes a rapid reduction in swelling, inflammation, and related pain as muscle fibers are heated, as well as relaxes muscles, relieves muscle pain, and reduces back and shoulder and neck pain.

Sinusitis is a common disease in society. Sinusitis is an inflammation of the nose and the symptomatic inflammation of the paranasal sinuses. For this reason, the definition of “rhinosinusitis” is considered more appropriate. Rhinosinusitis can be

classified as acute and chronic. Acute rhinosinusitis (ARS) is used for conditions that last less than four weeks, and chronic rhinosinusitis (CRS) is used for conditions that last longer than 12 weeks. Acute rhinosinusitis is an upper respiratory tract infection in which antibiotics are started immediately. However, this rhinosinusitis is often viral rhinosinusitis (VRS), resulting from the spread of a viral infection to the paranasal sinuses. Sometimes viruses and bacteria can also be a factor. VRS is very frequent all over the world, like the common cold. Narrowing of the sinus orifices, deterioration of ciliary activity, and darkening of the sinus secretions play an essential role in the formation of acute rhinosinusitis. Viral infections, primarily due to vascular congestion, cause mucosal edema and cause narrowing of the sinus mouth. The cost of the treatment of sinusitis is very high every year⁹⁻¹¹. Our goal was to examine whether FIR therapy can enhance the symptoms of sinusitis.

Materials and Methods

Study Groups

This study was conducted on 10 New Zealand rabbits of both sexes, 7-8 months old, with an average weight of 1.8-2.4 kg.

The animals were randomly divided into two groups, and the right and left side sinuses were accepted as different groups as follows.

- Group 1: right side of first five animals.
- Group 2: left side of first five animals.
- Group 3: right side of second 5 animals.
- Group 4: left side of second 5 animals.

Far-Infrared Treatment with Infra-Sin Device

We designed and built a steel-based device that produces infrared rays called Infra-Sin.

We had the device (Infra-Sin, Istanbul, Turkey), perform a thermographic examination. After thermographic inspection, it was determined that the infrared surface temperature was 546.2°C, and the infrared spectral band gap was between 7.5 µm and 14 µm.

Near-infrared/IR-A 0.7-1.4 µm (700-1,400 nm), mid-infrared/IR-B 1.4-3.0 µm (1,400-3,000 nm), far infrared/IR-C 3.0-100 µm (3,000 nm-0.1 mm) (1), our Infrasin™ device emits far infrared rays (Table I).

Experiment

Group 1: right side of first five animals

Merocel (Medtronic Inc., Minneapolis, MN, USA), one of the most common nonabsorbable

nasal packing materials, is a compressed, dehydrated sponge composed of hydroxylated polyvinyl acetate that can increase in size within the nasal cavity and compress a bleeding vessel through rehydration with normal saline, is placed to create sinusitis. They were kept there for 15 days. Paranasal sinus tomography was performed on the 15th day, and unilateral inflammation was detected in the sinuses (Figure 1A-B).

Group 2: left side of first five animals

The left side sinuses were accepted as the control of Group 1.

These animals (Groups 1 and 2) were given Far-Infrared Treatment with an Infra-Sin device for a week. The treatment was applied four times, 7 minutes every other day for two weeks, with a FAR Infrared device. FIR was applied from a 30 cm distance. The total treatment period was 49 minutes (Figure 2).

Group 3: right side of second 5 animals

Merocel is placed to create sinusitis, as done in Group 1. They were kept there for 15 days. Paranasal sinus tomography was performed on the 15th day, and unilateral inflammation was detected in the sinuses (Figure 1A-B).

Group 4: left side of second 5 animals

The left side sinuses were accepted as the control of Group 3.

These animals (Groups 3 and 4) were given Amoxicillin IM antibiotics at 15 mg/kg for four days. The left side of the nose of each rabbit was taken as the control group.

The animals were observed for nasal discharge twice daily during the experiment period. The animals were de-capitated at the end of the experiment period, and sinus mucosa samples were taken from all animals.

Histopathologic Evaluation

Tissue samples were fixed in 10% neutral buffered formalin, passed through a series of rising alcohol (70%, 90%, 96%, and 100%) and xylene, and embedded in paraffin.

Table I. Thermal data of the device Infra-Sin

| | |
|------------------------|---------------------|
| Background Temperature | 22.0°C |
| Emission Power | 0.95 |
| Transmission | 1.00 |
| Model of the Camera | TiS60 |
| IR Sensor Size | 260 x 195 |
| Display Time | 14.03.2022 09:49:30 |
| Infrared spectral band | 7.5 µm file 14 µm |

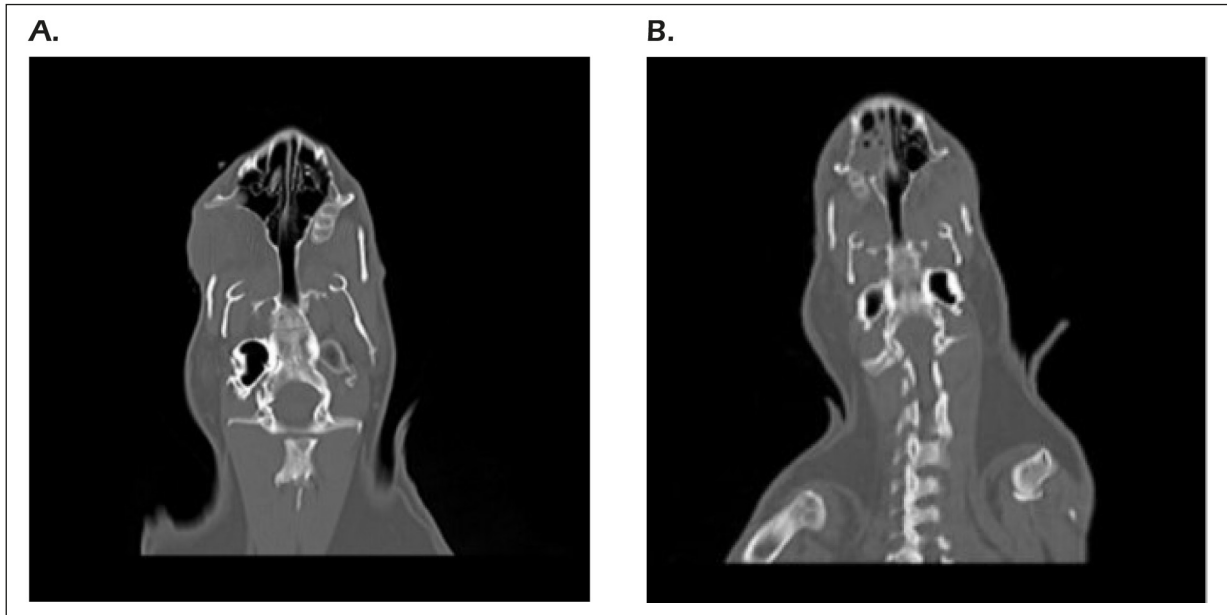


Figure 1. Thermal graph of the device Infra-Sin. **A**, Normal rabbit sinus tomography. **B**, Rabbit tomography with rhinosinusitis on the right side.

Sections of 5 μm thickness were taken with a microtome, stained with the Hematoxylin and Eosin (H&E), and examined with a light microscope (Carl Zeiss, AxioZoom Jena, Germany) at 200x magnification.

Mucosal samples were evaluated microscopically regarding epithelial eruption, epithelial vacuolization, interstitial edema, vascular congestion, leukocyte infiltration, and mucosal thickening.

Results

The experiment was finalized with all animals alive. It was determined that nasal discharge decreased gradually in both rabbits treated with infrared treatment and rabbits treated with antibiotics.

As a result, during the pathological examination the following results were shown.

Histological findings

Normal kinocilium and a regular and continuous mucosal epithelium were seen in Group 2. The mucosa's connective tissue, blood vessels, and gland structures were normal. No congestion or inflammation was observed in the tissue (Figure 3).

Whereas epithelial thickening, shedding in the kinocilium structure, thickening of the connective tissue in the mucosa, and vascular dilation were observed in Group 1 samples (Figure 4).

The Group 4 animal samples thickened mucosal epithelium and regular kinocilium structure and vascular dilatation, intense cell infiltration, and interstitial edema were observed (Figure 5).

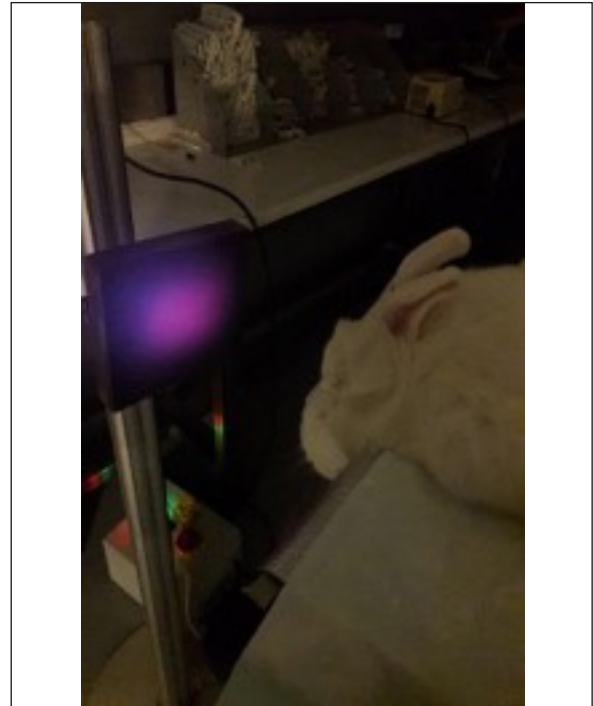


Figure 2. FIR application with the device Infra-Sin from a distance of 30 cm.

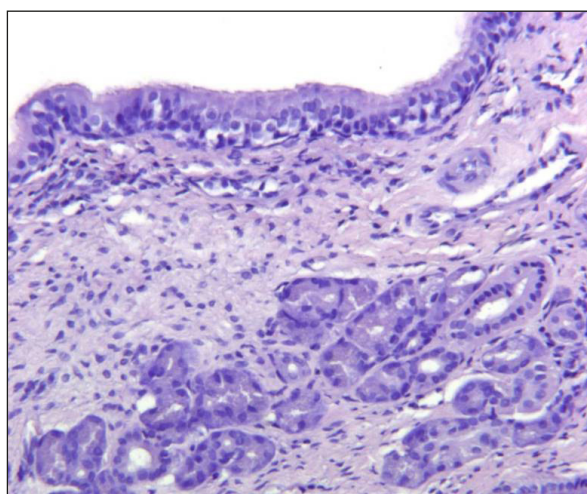


Figure 3. Group 2- Control group: Normal kinocilium and a regular and continuous mucosal epithelium (H&E, x200).

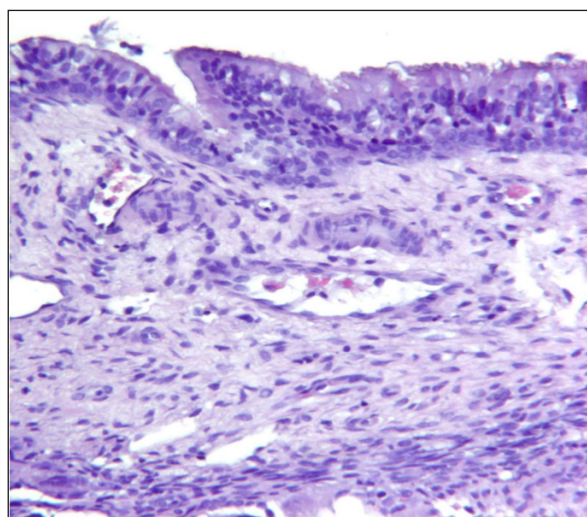


Figure 4. Group 1, Epithelial thickening, shedding in the kinocilium structure, thickening of the connective tissue in the mucosa, and vascular dilation (H&E, x200).

In Group 3 animals, vascular congestion, interstitial edema, connective tissue thickening, and intense cell infiltration were observed in the mucosa, and thickening, irregularity, and shedding in the mucosal epithelium (Figure 6).

According to the histopathological examinations, while the control groups, Group 2 and Group 4, showed a normal histological appearance, Group 1 and Group 3 showed a decrease in cell infiltration and mucosal degeneration due to damage and a decrease in mucosal damage, which was concluded as the proof of healing process.

We found clinical and histopathological improvement in rabbits with sinusitis on the right side of the

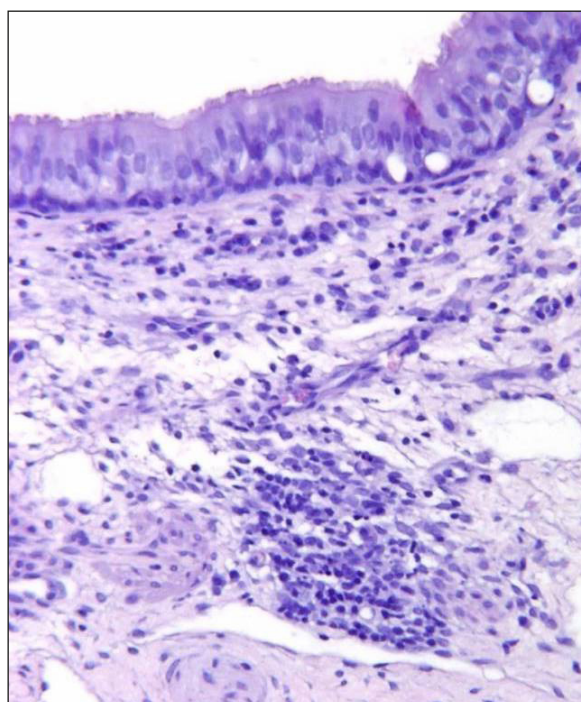


Figure 5. Sample of Group 4 (H&E, x200). In the Group 4 animal samples, thickened mucosal epithelium and regular kinocilium structure and vascular dilation, intense cell infiltration, and interstitial edema were observed.

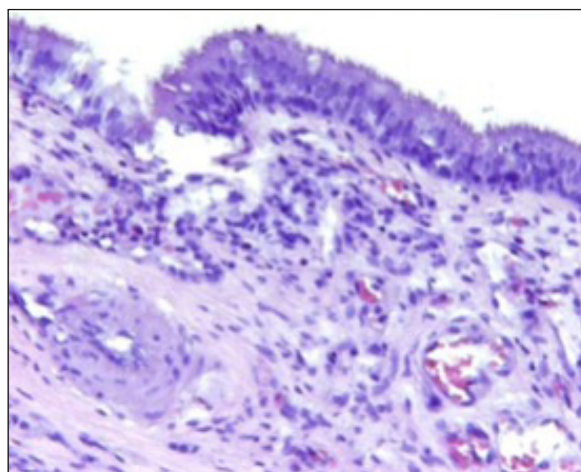


Figure 6. Sample of Group 3 (H&E, x200). In Group 3 animals, vascular congestion, interstitial edema, connective tissue thickening, and intense cell infiltration were observed in the mucosa, and thickening, irregularity, and shedding in the mucosal epithelium.

nose, to which we applied FIR treatment with the device Infra-Sin, which is very similar to or slightly better results obtained with antibiotic treatment.

Statistical analysis was not performed as the size of the histopathologic evaluation data was insufficient.

Discussion

Far-infrared rays have been used in many branches of medicine for a long time, and research has been and continues to be done on FIR. Far infrared (FIR) is an invisible electromagnetic wave with a longer wavelength than visible light. Infrared radiation has different wavelengths: near (0.8-1.5 µm), medium (1.5-5.6 µm), and far infrared (5.6-1,000 µm) separated as radiation. It has been reported to inhibit tumor growth in mice and is used to treat some vascular-related disorders¹⁻⁴. The experiment was planned to determine the effects of FIR in treating sinusitis with an Infra-Sin device, which has been proposed to be no different from ceramic-based far infrared radiation devices used in medicine.

Antibiotic treatment is the mainstay of sinusitis. Although they have been widely used, their adverse effects are well known. Especially microbiota is getting more and more important throughout the years. It is essential and beneficial keeping them intact and undisturbed¹³. We observed that far-infrared rays were as effective as antibiotics in sinusitis treatment. We did not observe any side effects. It may be a safe option for treating many infections in the future.

It has been shown in many studies^{1,2} that infrared rays penetrate up to 4 cm from the skin, increasing circulation and the metabolism of cells, which may be accepted as a positive factor for the healing process. Papers^{5,6} stating an “increased microcirculation” are also supporting this suggestion. We noticed that infrared rays were equally effective as antibiotic treatment in terms of healing. Toyokawa et al⁶ found that FIR increased the secretion of TGF-131 and skin blood flow in skin wound healing in their experiment with rats. They stated that increased activation of fibroblasts was beneficial in wound healing. This determination was also supportive of the results.

Furthermore, 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 the nonthermal effects of FIR.

There are common symptoms of allergic rhinitis and sinusitis. House dust, animal dander, mold spores, and pollen are the most frequent allergens that can cause allergic rhinitis, but there are many others. Sneezing, nasal itching, rhinorrhea, and nasal stuffiness occur when an allergic individual comes into contact with the allergen that triggers their condition. These symptoms result from affe-

rent nerve stimulation, glandular hypersecretion, increased vascular permeability, and the infiltration of inflammatory cells. Untreated AR patients' nasal mucosa produce much more nitric oxide (NO) than healthy controls¹⁴. L-arginine reacts with NO synthases found in endothelial cells, macrophages, neutrophils, mast cells, fibroblasts, and parasympathetic neurons to produce nitric oxide. The findings suggested that these factors mediate the onset of an allergic reaction and, in concert, are responsible for the typical symptomatology. Endothelial nitric oxide synthase expression was upregulated after repeated FIR therapy, as reported by Akasaki et al¹⁵.

Conclusions

Our findings in this animal study led us to conclude that it would be beneficial to study the effects of FIR treatment on people with allergic rhinitis and sinusitis and to identify the optimal dosing, treatment duration, and intensity. To add to our findings, looking into whether FIR therapy can be used as an alternative to antibiotic treatment for human sinusitis is essential.

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Authors' Contributions

All authors designed the study together; they collected and analyzed data, and wrote the manuscript. They all contributed equally to the manuscript and read and approved the final version.

Ethics Approval

Bezmialem Foundation University, the Local Ethics Committee for Animal Experiments approved the study (No.: 2017/301).

Informed Consent

Not applicable.

Conflicts of Interest

The authors declared no potential conflicts of interest concerning this article's research, authorship, and publication.

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