The phototherapeutical method is also effective for the prevention of inflammatory or hyperproliferative diseases.
FIG. 9
200

Providing a phototherapeutical apparatus, comprising a light source, an optical guidance system and a patient interface

206

Preparing for the application of the apparatus

212

Generating high intensity visible/ultraviolet light with the light source

216

Coupling the generated light into the patient interface

220

Applying the high intensity visible/ultraviolet light by the patient interface to a diseased nasal mucosa, wherein the disease is allergic rhinitis or nasal polip

FIG. 10.
PHOTOTHERAPEUTICAL METHOD AND SYSTEM FOR THE TREATMENT OF INFLAMMATORY AND HYPERPROLIFERATIVE DISORDERS OF THE NASAL MUCOSA

CROSS REFERENCE TO RELATED APPLICATIONS


BACKGROUND

[0002] 1. Field of Invention

[0003] The present invention relates to the treatment and prevention of inflammatory and hyperproliferative diseases of body cavities, more particularly to the treatment and prevention of diseases of the nasal cavity by phototherapeutical methods.

[0004] 2. Description of Related Art

[0005] The treatment and prevention of inflammatory diseases of the nasal mucous membrane and paranasal sinuses is an unsolved problem. These diseases include allergic rhinitis, commonly referred to as hay fever, vasomotor rhinitis, non-allergic eosinophilic rhinitis, chronic sinusitis, which is the inflammation of the paranasal sinuses, and nasal polyps.

[0006] Rhinitis is an inflammatory disorder of the nasal mucous membrane, which is characterized by nasal itch, sneeze, nose running, nasal blockage, and rarely by loss of smelling. The inflammation of the nasal mucous membrane is frequently associated with the inflammation of the paranasal sinuses (rhinosinusitis, chronic sinusitis). As a consequence of the frequent and persistent inflammation of the mucous membrane hyperproliferative lesions, or so-called polyps develop on the mucous membrane.

[0007] One characteristic disease is the allergic rhinitis, commonly referred to as hay fever. The allergic rhinitis is the most frequent allergic disease affecting 10-20% of the population. The number of patients with allergic rhinitis, especially in the well developed industrial countries increased very rapidly in the last few years. Because of the high number of patients the direct and indirect costs of this disease are great.

[0008] Although hay fever is not a very severe disease, its unpleasant symptoms worsen the quality of life considerably. Hay fever is frequently associated with allergic conjunctivitis and sometimes with general symptoms. The symptoms last only for a few months in some patients (seasonal rhinitis), while in others they last the whole year (perennial rhinitis).

[0009] The symptoms of the allergic diseases develop as follows. An allergen enters the body and induces the production of a specific IgE, which binds to specific receptors on the surface of mast cells. After subsequent exposure the allergen crosslinks the IgE receptors, resulting in mediator release from the mast cells. These mediators are responsible for the development of the symptoms in patient.

[0010] As a result of this activation histamine and other preformed mediators are released from the mast cells. In the mast cells new inflammatory mediators are produced attracting further inflammatory cells into the mucous membrane (Howarth P H, Salagean M, Dokić D: Allergic rhinitis: not purely a histamine-related disease. Allergy 55: 7-16, 2000).

[0011] At present there is no treatment for rhinitis, which would result in a complete elimination of the symptoms. The increased number of inflammatory cells in the nasal mucous membrane release mediators, which are responsible for the clinical symptoms. Often antihistamines are used locally or systemically for the blocking of the released mediators. Sodium cromoglycate is available for the inhibition of the release of mediators. Finally, corticosteroids are used locally or systemically for the blocking of the synthesis of new mediators. In special cases a desensitizing therapy might be used. The pathogenesis of the development of the clinical symptoms is already well known. However, the presently available drugs often do not eliminate the symptoms. Therefore, every new method for the treatment of this disease has a great medical significance.

[0012] A further characteristic disease is vasomotor rhinitis. Vasomotor rhinitis is an inflammatory disorder of the nasal mucous membrane with unknown origin. The clinical symptoms are largely similar to that of allergic rhinitis: permanent nasal blockage, nasal itch, sneeze, nose running, and rarely loss of smelling. Mastocyte-activating mediators cause the symptoms. These are released from the nerve endings of the nasal mucous membrane upon irritation.

[0013] A further characteristic disease is the nonallergic eosinophilic rhinitis. This disease is characterized by the high number of eosinophils in the nasal secretions and by the lack of an allergic origin. The disease is frequently associated with the development of nasal polyps, the hyperproliferative condition of the nasal mucous membrane. The clinical symptoms are the same as in allergic rhinitis.

[0014] Additional diseases are rhinosinusitis and sinusitis. The inflammation of the paranasal sinuses is frequently associated with the inflammatory condition of the nasal mucous membrane (nasosinusitis). The isolated inflammation of the paranasal sinuses is also a frequent disease (sinusitis). This disease has often an allergic origin, although its exact cause remains unknown. There is no well-tested treatment, thus usually the same therapy is used as for rhinitis.

[0015] Ultraviolet light has been used for more than twenty years for the treatment of allergic and auto-immune skin diseases. In various treatments and procedures ultraviolet B light (280 nm-320 nm) and ultraviolet-A light (320 nm-400 nm) is used typically. The ultraviolet light inhibits the antigen-induced cellular immune response and is able to induce tolerance (Streilein J W, Bergstresser P R: Genetic basis of ultraviolet-B on contact hypersensitivity. Immuno-genetics 27: 252-258, 1988).

[0016] The ultraviolet light suppresses the immune reaction by inhibiting the antigen presentation and by inducing T-cell apoptosis. Irradiation of the skin with ultraviolet-B light or ultraviolet-A light on an area previously photosen-

sitzed by psoralen is known to inhibit the immunological processes in the skin. For the treatment of skin diseases there are a number of phototherapeutical devices available.

[0017] These phototherapeutical devices include ultraviolet light sources. These light sources might be classified based on, for example, their operational principle, output energy or power, mode of operation (impulse or continuous), and whether they are emitting monochromatic or multivavelength light.


[0020] Phototherapeutical treatments improved significantly with the appearance of ultraviolet light delivering optical systems. Such an ultraviolet light delivering phototherapeutic system with fiber optic is used in the Saalmann Cup instrument, in which the concentrated ultraviolet light is coupled into a fiber optic cable. Therefore, it is suitable for the treatment of smaller lesions of the skin or mucous membrane (Taub E M, Friedler H: Hochkonzentrierte UV Bestrahlung kleiner Hautbezirke mit einem neuen Punktstrahler. Grundlagen und klinische Ergebnisse. Deutsche Dermatologe, 10: 1453, 1992).

[0021] However, the Saalmann Cup can not be introduced into smaller body cavities because of its large contact area and because of the thickness of the used fiber optic cable. This device can be used in body cavities where the distal end of the fiber optic cable and the area to be treated can be visually controlled, such as the oral cavity. For this reason, this device is unsuitable for the treatment of body areas, which cannot be visually controlled, such as the nasal and paranasal mucous membrane, the gastrointestinal, and the urogenital mucous membrane.

[0022] Although ultraviolet light has been used for the treatment of hyperproliferative and inflammatory skin diseases for many years, it has not been used for the treatment of common, immunologically mediated disorders of the nasal mucous membrane. In the U.S. Patent Application by Lajos Kemény, Zsolt Bor, Gábor Szabó, Ferenc Ignác, Béla Rác, and Attila Dobozay, entitled: “Phototherapeutical Apparatus and Method for the Treatment and Prevention of Diseases of Body Cavities”, filed Apr. 9th 2003, hereby incorporated by reference in its entirety, a phototherapeutical apparatus and method was described for the treatment of inflammatory and hyperproliferative disorders of the nasal mucosa and paranasal sinuses, such as allergic and nonallergic rhinitis, vasomotor rhinitis, allergic rhinosinusitis, and nasal polyps. This method utilized ultraviolet light. Ultraviolet light was reported to be effective for the treatment of different forms of rhinitis, including hay fever. Also, ultraviolet light suppressed the development of nasal polips.

[0023] Neuman and Finkelstein used narrow-band, low energy, red-light phototherapy for the treatment of the nasal mucous membrane and they found it effective for perennial allergic rhinitis but not for nasal polyposis (Neuman I., Finkelstein Y. Narrow-band red light phototherapy in perennial allergic rhinitis and nasal polyposis. Ann Allergy Asthma Immunol 78: 399-406, 1997). Neumann and Finkelstein irradiated the nasal mucosa using a 660 nm light emitting diode (LED) with a dose of 3 J/m²/day. They referred to their treatment as “a low-energy stimulation” as they used a 4 mW light emitting diode. As the total surface of the mucosa of one nostril is approximately 15 cm², the nasal mucosa was illuminated with a total daily dose of approximately 0.2 J/cm².

[0024] In our patients cohort, we were not able to demonstrate the efficacy of this low energy, low intensity red light phototherapy for the treatment of hay fever. It should be noted, however, that high energy, high intensity visible light phototherapy has not previously been used for the treatment of inflammatory and hyperproliferative disorders of the nasal mucosa and paranasal sinuses such as allergic and non-allergic rhinitis, vasomotor rhinitis, allergic rhinosinusitis, and nasal polips.

[0025] The photodynamic therapy (PDT) has been used for the last hundred years for the treatment of cancers. Many studies confirmed the efficacy of PDT for the treatment of different tumors in the last 30 years. In topical PDT, 5-aminolevulinic acid (ALA) is applied into the area to be treated. ALA is converted in situ into the active endogenous photosensitizer protoporphyrin IX, which sensitizes the hyperproliferative cells. Illumination of the lesions with high intensity visible light results in the production of singlet oxygen molecules, the presence of which causes the subsequent death of the sensitized cells.

[0026] Recently a new, highly selective photosensitizer compound, methyl 5-aminolevulinate has also been introduced for use in topical PDT and many different studies confirmed its efficacy for the treatment of premalignant and malignant skin lesions (R. Széimes et al.: Photodynamic therapy using topical methyl 5-aminolevulinate compared with cytotherapy for actinic keratoses: a prospective randomized study. Journal of the American Academy of Dermatology, vol. 47, p. 258, 2002) Although PDT has been used in many applications, it has not been used for the treatment of hay fever or nasal polips yet.

[0027] There are a number of ultraviolet light delivery systems, which use lasers. For example, the light of the 308 nm xenon chloride excimer laser can be guided by fiber optic cable for the cleaning of root canals by ablation ( Folwaczny M, Mehl AL, Hafta C, Hickel R: Substance removal on teeth with and without calculus using 308 nm XeCl excimer laser radiation. An in vitro investigation. J. Clin. Periodontol 26: 306-12, 1999). The 308 nm xenon chloride excimer laser is also suitable to treat atherosclerosis by treating the blood vessel walls (U.S. Pat. No. 4,686,979), or to enhance the cardiac oxygenization with transmyocardial laser revascularisation (U.S. Pat. No. 5,976,124), or inhibiting neovascularisation during angioplasty by destroying myocardial cells (U.S. Pat. No. 5,053,033).

[0028] These systems share the common feature that the high-energy ultraviolet light at the end of the light delivering
system is focused on small areas of only a few hundred microns in diameter. The photoablation produced by the intense ultraviolet light removes the undesired material. However, the intense ultraviolet light damages the tissues with its ablative effect.


[0030] Phototherapeutical systems attached to endoscopes are also used for the photodynamic treatment of tumors, such as bladder carcinoma or bronchial cancer. However, these instruments have special distal ends for tumor treatment (U.S. Pat. Nos. 4,313,431; 4,612,938; 4,676,231; 4,998,930; 5,146,917).

[0031] At present, the phototherapeutical systems delivering light consist of a hand piece specifically shaped to a specific treatment. As such, they are either unsuitable or inconvenient for the treatment of small body cavities such as the nasal cavity with visual control.

SUMMARY

[0032] Briefly and generally, embodiments of a phototherapeutical apparatus are described, the apparatus including: a light source, operable to generate high intensity visible light, an optical guidance system, operable to receive and guide the high intensity visible light of the light source, and a patient interface, operable to receive the guided light from the optical guidance system, wherein the patient interface is operable to apply the guided light to a tissue surface of a nasal cavity. In some embodiments the patient interface is insertable at least partially into a nasal cavity.

[0033] Further, embodiments of a method of treating diseases is described. The method includes providing a phototherapeutical apparatus, which includes a light source, operable to generate high intensity visible light, an optical guidance system, coupled to the light source, and a patient interface, coupled to the optical guidance system. The method further includes preparing for the application of the phototherapeutical apparatus, inserting at least partially the patient interface into a nasal cavity, generating high intensity visible light with the light source, coupling the high intensity visible light into the patient interface through the optical guidance system, and applying the high intensity visible light by the patient interface to a tissue surface of the nasal cavity, wherein the tissue of the nasal cavity has an inflammatory disease or a hyperproliferative disease.

[0034] Examples of inflammatory diseases include the inflammatory diseases of the nasal cavity. Research showed that single or repeated irradiation of the nasal mucous membrane and paranasal sinuses with high intensity visible light, or with a combination of visible light with ultraviolet light (of the UVB or UVA type, or both) suppress the clinical symptoms of rhinitis, sinusitis, and rhinosinusitis, and result the regression of nasal polyps.

[0035] In some embodiments of the phototherapeutical method photodynamic therapeutic methods are included, where a photosensitizing substance, such as deltaaminolevulinic acid is applied to the tissue surface before irradiation with light.

[0036] The phototherapeutical apparatus is also effective for the prevention of inflammatory diseases or hyperproliferative diseases. In these embodiments of the method phototherapy is applied before the appearance of clinical symptoms of the disease.

BRIEF DESCRIPTION OF DRAWINGS

[0037] For a more complete understanding of the present invention and for further features and advantages, reference is now made to the following description taken in conjunction with the accompanying drawings.

[0038] FIG. 1 illustrates an embodiment of the phototherapeutical apparatus according to the invention.

[0039] FIGS. 2A-B illustrate exemplary implementations of the light source and the phototherapeutical apparatus according to an embodiment of the invention.

[0040] FIG. 3 illustrates an exemplary implementation of the optical coupling unit according to an embodiment of the invention.

[0041] FIG. 4 illustrates an exemplary implementation of the patient interface according to an embodiment of the invention.

[0042] FIG. 5 illustrates an exemplary implementation of the patient interface according to an embodiment of the invention.

[0043] FIG. 6 illustrates an exemplary implementation of the patient interface according to an embodiment of the invention.

[0044] FIG. 7 illustrates an exemplary implementation of the patient interface according to an embodiment of the invention.

[0045] FIG. 8 illustrates an exemplary implementation of the patient interface according to an embodiment of the invention.

[0046] FIG. 9 illustrates a phototherapeutical apparatus including a flexible endoscope, according to an embodiment of the invention.

[0047] FIG. 10 illustrates steps of the phototherapeutical method, according to an embodiment of the invention.

[0048] FIG. 11 illustrates the decrease of clinical symptoms due to treatment with an embodiment of the phototherapeutical method, according to an embodiment of the invention.

[0049] FIG. 12 illustrates the decrease of clinical symptoms due to treatment with an embodiment of the photodynamic therapeutic method, according to an embodiment of the invention.

DETAILED DESCRIPTION

[0050] Embodiments of the present invention and their advantages are best understood by referring to FIGS. 1-12 of the drawings. Like numerals are used for like and corresponding parts of the various drawings.

[0051] The Phototherapeutical Apparatus

[0052] The phototherapeutical apparatus, according to embodiments of the present invention is suited for the
treatment and prevention of common inflammatory diseases of the body. In some applications the phototherapeutical apparatus is used for the treatment and prevention of the diseases of a nasal mucous membrane and paranasal sinuses such as allergic rhinitis (hay fever), vasomotor rhinitis, nonallergic eosinophilic rhinitis, chronic sinusitis (inflammation in the paranasal sinuses), or nasal polyps. Some embodiments of the phototherapeutical apparatus utilize visible light. Some embodiments utilize a combination of visible light and ultraviolet light. Some embodiments utilize high intensity light.

[0053] FIG. 1 illustrates a phototherapeutical apparatus 100, according to an embodiment of the invention. Phototherapeutical apparatus 100 includes a light source 1. Light source 1 is operable to generate a light beam 2 of visible light, ultraviolet light, or a combination of visible and ultraviolet light. Light source 1 is operable to generate high intensity light. Light beam 2 enters into an optical coupling unit 3, where light beam 2 is focused. The focused light beam is coupled by optical coupling unit 3 into an optical guidance system 4. Optical guidance system 4 guides the focused light beam into a patient interface 5. Patient interface 5 is insertable at least partially into a body cavity, where it applies the light beam to a tissue surface of a body cavity. FIG. 1 illustrates an embodiment, where the body cavity is the nasal cavity and the patient interface is inserted through a nostril 6.

[0054] In some embodiments light source 1 generates a continuous light beam, in others a slowly oscillating light beam. For example, in some embodiments the frequency of oscillations can be below about 100 Hertz. In various embodiments the continuous light beam and slowly oscillating light beam will be jointly referred to as quasi-continuous light beam.

[0055] Light source 1 can be, for example, a monochromatic light source or a multiwavelength light source.

[0056] A variety of monochromatic light sources, such as lasers, can be used as light source 1. Examples include any type of diode lasers or other lasers emitting high intensity light in the visible spectrum. Also, a variety of multiwavelength light sources can be used as light source 1. Examples include electric discharge lamps, arc lamps filled with xenon, mercury vapour, xenon and mercury vapour, fluorescent lamps, and light emitting diodes (LEDs).

[0057] In some embodiments substantially all of the light, generated by light source 1, is visible light, i.e. it has a wavelength in the visible spectrum, between about 400 nm and about 700 nm. In some embodiments the wavelength is in the high energy portion of the visible spectrum, between about 400 nm and about 600 nm.

[0058] In embodiments the generated visible light has a dose up to about 100 J/cm² on the targeted tissue. In some embodiments light beams with a dose between about 10 J/cm² and about 100 J/cm² will be referred to as high intensity light. The range of the dose of the light may depend on the specific patient. For some patients a light with a dose of, for example 4 J/cm² or 7 J/cm² may be already high intensity.

[0059] In some embodiments light source 1 generates a certain amount of ultraviolet light simultaneously with the visible light. The ultraviolet light can have a wavelength in the ultraviolet-B (280 nm-320 nm) and ultraviolet-A (320 nm-400 nm) part of the spectrum.

[0060] FIG. 2A illustrates an example of light source 1, operable to generate visible light, ultraviolet light, or a combination of visible and ultraviolet light, according to embodiments of the invention. An electric power supply unit 7 is connected to electrodes 11 by wires 8. Electrodes 11 enter the internal space of quartz bulb 12, which is filled with gas. The electric power, provided by electric power supply 7, causes an electric discharge in the gas. During this discharge light is generated. The wavelength of the light depends, among others, on the chemical composition of the gas. With a suitable choice of the chemical composition of the gas the generated light will have a wavelength in the visible spectrum or in the ultraviolet spectrum. In some embodiments the gas or gas mixture in quartz bulb 12 can include xenon, argon, and mercury vapor, and any other gas that emit light substantially in the visible spectrum, possibly with a portion emitted in the ultraviolet spectrum. Part of the light, generated in the discharge space, propagates directly towards focusing lens 15. Other portions of the generated light propagate in other directions. Part of these portions are reflected by concave mirror 9 towards focusing lens 15. Focusing lens 15 focuses all incoming light efficiently into a light beam 2. The focused light beam 2 leaves housing 10 through an output opening 14 and reaches an optical filter 13. In some embodiments optical filter 13 transmits visible light, ultraviolet A, or ultraviolet B, or any combination of light. From optical filter 13 the filtered and focused light beam 2 is coupled into an optical guidance system 4.

[0061] The volume of the discharge space in quartz bulb 12 varies in the range of about 1 mm³ to about 0.1 mm³. In some embodiments the discharge space is positioned approximately in the focus of concave mirror 9, so concave mirror 9 can efficiently focus the emitted light onto focusing lens 15.

[0062] FIG. 2B illustrates a phototherapeutical apparatus 100, according to a related embodiment of the invention. Power supply 7 provides adjustable power for apparatus 100. Power supply 7 may include a medical grade isolation transformer. The isolation transformer also provides protection from electrical shock. Quartz bulb 12 is operable to generate light with a wavelength between about 280 nm and about 700 nm. In some embodiments quartz bulb 12 is operable to generate light with a wavelength between about 280 nm and about 600 nm. An embodiment of quartz bulb 12 is an electric microdischarge lamp. In embodiments the length of discharge space, or "arc", is between about 1 mm and about 10 mm. Because of the smallness of the discharge volume it is easy to collect the generated light and to couple it into optical guidance system 4. As an example, an electric micro-discharge lamp with a power of about 35 watts may output between about 0.1 watts to about 2 watts at patient interface 5.

[0063] Previous examples of arc lamps include mercury and mercury xenon lamps, described, for example, by Hartmann et al. in Patent Application WO 02/13905. In these lamps the discharge space is bigger. Accordingly, these lamps need a power of 500 to 1500 watts to output 2 to 4 watts at patient interface 5. In contrast, embodiments of the present invention utilize micro-discharge lamps. These substantially smaller discharge lamps can operate with a power
of about 35 watts. Micro-discharge lamps also produce much less heat. Therefore, in some embodiments no ventilation is necessary to cool the micro-discharge lamp during usage. Because of the small lamp size some embodiments of the phototherapeutical device are portable. For example, embodiments of the device can be powered through the cigarette lighter of an automobile.

[0064] The generated light beam 2 is coupled by optical coupling unit 3 into optical guidance system 4. Optical coupling unit 3 includes optical filter 13 and beam shutter 110. Optical filter 13 is operable to select a range of wavelengths from the overall wavelength range of light beam 2. Commercially available optical filters 13 include SCHOTT GG 400 (manufactured by Schott A. G., Germany), which is operable to filter out the ultraviolet portion of light beam 2 with wavelengths below about 400 nm. Optical filter SCHOTT WG 320 (Schott A. G., Germany) is operable to filter out the ultraviolet-B portion of the spectrum, below about 320 nm. Beam shutter 10 is controlled and monitored by a control panel 106. Control panel 106 may include an electronic timing unit, which is operable to log the operational ON time of power supply 7. The intensity of light beam 2 is adjustable by controlling the current output of power supply 7. Phototherapeutical apparatus 100 can be pre-programmed through control panel 106. Pre-programming may include selecting a treatment irradiant dosage by setting the timing unit and adjusting the intensity of light beam 2 by setting the current of power supply 7. Some embodiments may include a footswitch 104. Footswitch 104 can be used to convenient application of apparatus 100. For example, footswitch can be used to start a pre-programmed application of apparatus 100.

[0065] Light beam 2 is coupled by optical coupling unit 3 into optical guidance system 4. Optical guidance system 4 might provide additional optical filtering. Embodiments of optical guidance system 4 include an optical cable with a core diameter between about 1 mm and about 10 mm. Optical guidance system 4 couples light beam 2 into patient interface 5. Patient interface 5 may be inserted into the nasal cavity of a patient. FIG. 2B shows a hollow plastic tip as a patient interface 5. Several additional embodiments of patient interface 5 will be described below. Patient interface 5 might also provide additional optical filtering. Patient interface 5 may include a tip which transmits visible light but does not transmit ultraviolet light, or a tip which transmits both visible and ultraviolet light.

[0066] FIG. 3 illustrates an embodiment of optical coupling 3. Light beam 2 entering optical coupling unit 3 is directed by a dichroic mirror 16 into optical guidance system 4 through a lens system 17. Dichroic mirror 16 simultaneously performs a spectral filtering of light beam 2.

[0067] In some embodiments optical guidance system 4 is also applicable to guide back reflected light, reflected from the site of application. The light emerging from the site of the application passes dichroic mirror 16 and can be detected through an observing optical device 19 to assist the application of the phototherapeutical device.

[0068] Optical guidance system 4 can be, for example, an optical cable or arm suitable to guide light. The optical cable or arm can be formed of any one of a large number of known suitable materials, among others quartz glass or capillary tubes filled with a liquid capable of guiding light, wherein the internal surface of the capillary tubes are covered with ultraviolet reflecting material. The diameter of the optical cable can be between about 1 micron and about 10 mm. In some embodiments optical guidance system 4 also performs a spectral filtering of light beam 2.

[0069] FIG. 4 illustrates an embodiment of patient interface 5, suitable for the treatment of the nasal mucous membrane and paranasal sinuses. Patient interface 5 is suited to be positioned at least partially in the nostril or nasal cavity of a patient and guide light beam 2 onto the tissue surface to be treated. Many variations of patient interface 5 can be constructed and are meant to be within the scope of the invention.

[0070] In the embodiment of FIG. 4, optical guidance system 4 is attached to handgrip 20. The guided light enters from optical guidance system 4 through handgrip 20 into optical tube 22 and propagates into a tapered end piece 24. A head 25 of patient interface 5 is coupled to optical tube 22 by a fastener 23. A scanning light source 27 is included to illuminate the area of the tissue surface to be treated. Scanning light source 27 is built into handgrip 20 and can be powered by either an internal or an external power supply unit. Mirror 28 reflects the scanning light of scanning light source 27 onto the tissue surface to be treated. Light beam 2 and the scanning light propagate through output opening 26 onto the tissue surface to be treated. The end of patient interface 5, where light beam 2 leaves patient interface 5 is sometimes referred to as the distal end. In the present embodiment the distal end is where output opening 26 is positioned. A magnifying glass 21 mounted onto patient interface 5 provides visual control of the application of the light of phototherapeutical apparatus 100.

[0071] FIG. 5 shows another embodiment of patient interface 5, wherein the light beam 2 enters from optical guidance system 4 through a lens 29 of handgrip 20. Light beam 2 is then reflected on dichroic mirror 16, which is mounted inside optical tube 22, and leaves patient interface 5 through output opening 26 of head 25. In this embodiment scanning light source 27 is mounted inside handgrip 20. The scanning light passes through dichroic mirror 16 and is reflected by concave hole mirror 30 to illuminate the tissue surface to be treated.

[0072] In various embodiments external scanning light sources are applied to illuminate the tissue area to be treated.

[0073] FIG. 6 illustrates another embodiment of patient interface 5. In this embodiment optical guidance system 4 is coupled into a pen-shaped handgrip 31. Light beam 2 enters pen-shaped hand grip 31 and is reflected by flat surface 32. Flat surface treating head can include, among others, a quartz prism or a flat mirror. Flat surface treating head 32 is coupled to pen-shaped handle 31 with a fastener 23.

[0074] FIG. 7 illustrates another embodiment of patient interface 5, which is suitable for the circular treatment of a body cavity, for example, the nasal cavity. In this embodiment optical guidance system 4 guides light beam 2 into pen-shaped grip 31, where it is reflected by circular reflector 33 in a circular manner. Circular reflector 33 can be, for example, a conical or a spherical reflecting surface. Circular applicator head 34, housing circular reflector 33, is coupled to pen-shaped handle 31 with fastener 23. Body cavities, such as the nasal cavity can be treated with this embodiment in a circular manner.
FIG. 8 illustrates another embodiment of patient interface 5, which is suited for a spot treatment of tissue surfaces, such as the nasal mucous membrane. Light beam 2 generated by light source 1 is focused and coupled by optical coupling unit 3 into optical guidance system 4. Optical guidance system is integrated into flexible endoscope 37. Flexible endoscope 37 is equipped with patient interface 5. Patient interface 5 includes a spot applicator 36. Spot applicator 36 can be, for example, a plano-parallel disk or a lens 36 made of quartz or plastic transparent to light. Spot applicator 36 is housed by spot applicator head 35, which is fastened onto pen-shaped handle 31 by a fastener 23.

FIG. 9 illustrates another embodiment of patient interface 5, which is suited for a spot treatment of tissue surfaces, such as the nasal mucous membrane. Light beam 2 generated by light source 1 is focused and coupled by optical coupling unit 3 into optical guidance system 4. Optical guidance system is integrated into flexible endoscope 37. Flexible endoscope 37 is equipped with patient interface 5. Patient interface 5 includes a spot applicator 36. Spot applicator 36 can be, for example, a plano-parallel disk or a lens 36 made of quartz or plastic transparent to light. In some embodiments spot applicator 36 can have a sloped distal end.

In order to illuminate the tissue surface to be treated, a scanning light is provided by scanning light source 27. The generated scanning light is guided through lens 41 into scanning optical cable 42. Scanning optical cable 42 can be also integrated into flexible endoscope 37. The scanning light illuminates the tissue surface to be treated through patient interface 5.

Light reflected from the illuminated tissue surface is conducted back from the illuminated tissue surface via image processing optical cable 38, which can be integrated into flexible endoscope 37 as well. Image processing optical cable 38 is coupled into image processing unit 39 to facilitate visual control of the application of the phototherapeutical apparatus.

In some embodiments optical guidance system 4 can be rotated within flexible endoscope 37 by positioning unit 40, so that the direction of light beam 2 emitted through patient interface 5 can be modified. In other embodiments flexible endoscope 37 itself can be rotated by positioning unit 40. These embodiments are useful for the treatment of various body cavities, for example, a larynx, a digestive canal, and urogenital organs.

Some embodiments for the circular and the spot treatment of tissue surfaces may include a Panoramic Annular Lens (PAL) optical system. A PAL system, transparent to the light can be included into a circular applicator head 34 and spot applicator head 35. Including a PAL optical system can be helpful for simultaneous treatment of tissue surfaces and optical image processing.

A Phototherapeutical Method

According to embodiments of the invention, a phototherapeutical method 200 is described for the treatment and prevention of inflammatory and hyperproliferative diseases of body cavities, more particularly for the treatment and prevention of common inflammatory diseases of the nasal mucous membrane and paranasal sinuses, including allergic rhinitis (hay fever), vasomotor rhinitis, nonallergic eosinophilic rhinitis, chronic sinusitis (inflammation in the paranasal sinuses), and for the treatment and prevention of hyperproliferative diseases, including nasal polyps (a frequent benign hyperproliferative lesion in chronic inflammatory conditions of the nasal mucous membrane).

A Phototherapeutical method 200 is based on the inventor's research results, which showed that the application of visible light, or a combination of visible and ultraviolet light to tissues in the nasal cavity decreases the number and the activity of inflammatory cells (mast cells, eosinophils, and lymphocytes) responsible for the mediator release and synthesis in the mucous membrane, and thereby it reduces the clinical symptoms of inflammatory, hyperproliferative, and allergic diseases.

FIG. 10 illustrates steps of phototherapeutical method 200. In step 204 phototherapeutical apparatus 100 is provided, wherein phototherapeutical apparatus 100 includes: light source 1, optical guidance system 4, coupled to light source 1, and patient interface 5, coupled to optical guidance system 4. Phototherapeutical method 200 can be practiced with any embodiment of phototherapeutical apparatus 100, described earlier.

In some embodiments, light source 1 is operable to generate high intensity visible light. High intensity light includes light with a dose between about 10 J/cm² and about 100 J/cm². In some embodiments light source 1 generates visible light in the high energy portion of the spectrum, with wavelength between about 400 nm and about 600 nm. When visible light is used alone, without combination with UV light, high intensity light achieves significant immunosuppression in the nasal mucosa. The present method of using high intensity visible light differs from other methods using low-intensity light emitting diodes. Some low-intensity methods apply red light in a dose of about 0.2 J/cm², therefore the present method applies light in orders of magnitude higher doses.

In step 204 some embodiments of phototherapeutical apparatus 100 include essentially monochromatic light sources, other embodiments include multil wavelength light sources. Embodiments with monochromatic light sources include, for example, any type of diode lasers, or any other lasers, which emit light in the visible spectrum.

Multiple wavelengths embodiments include, for example, incandescent lamps and arc lamps. Each of these lamps can be filled, for example, with xenon, mercury vapour, and a mixture of xenon and mercury vapour. Other embodiments include fluorescent lamps, light emitting diodes (LEDs), and dye lasers.

In step 206 a preparation for the treatment by phototherapeutical method 200 is performed. The preparation can include—in case of a combined visible and ultraviolet light treatment—determining a light threshold of the particular patient on a part of the patient’s skin, which was not recently exposed to sunlight. One measure of a light threshold is the Minimal erythema Dose (MED). The MED is the smallest dose of combined light, which causes erythema on the patient’s previously unexposed skin after 24 hours. The MED is then used to determine the value of the first dose, applied to the area to be treated. The preparation can further include treatment of the nasal mucosa with nasal decongestants to decrease the edema of the nasal mucosa in order to be able to illuminate larger mucosa surfaces.

The preparation can further include selecting a suitable patient interface 5 for practicing phototherapeutical
method 200. This choice depends, for example, on the location of the area of the tissue surface to be treated and the anatomy of the body cavity of the patient.

[0090] In step 212 high intensity visible light beam 2 is generated by light source 1.

[0091] In step 216 the generated high intensity visible light beam 2 is coupled into patient interface 5 through optical guidance system 4.

[0092] In step 220 the generated high intensity visible light is applied by patient interface 5 to a tissue surface of a nasal cavity. In some embodiments of the method, step 220 includes inserting patient interface 5 at least partially into the nasal cavity. Patient interface 5 is inserted at the distal end.

[0093] In some embodiments of step 220, where the tissue surface is the nasal mucous membrane, a high intensity visible light was applied through patient interface 5 with a dose between about 10 J/cm² and about 100 J/cm².

[0094] The treatment with such high intensity visible light can be repeated one or more times per week. The repeated application of such high intensity visible light can be performed with the same dose or with increasing doses, depending on the patient’s tolerance and on the improvements of the clinical symptoms.

[0095] In some embodiments of step 220, where the tissue surface is the nasal mucous membrane, the high intensity visible light was applied in a dose between about 10 J/cm² and about 100 J/cm² of wavelength between about 400 nm and about 600 nm.

[0096] Research indicated that the clinical symptoms of the treated nasal mucous membrane improved considerably with the treatment. These symptoms include nasal blockage, nasal itch, nose running, sneezing, and itching of the palate in patients with allergic rhinitis.

[0097] In several cases the symptoms improved when high energy visible light was applied, or visible light in combination with ultraviolet light.

[0098] In some embodiments of the method, the previously determined MED value is used to determine the first dose, applied to the tissue surface to be treated.

[0099] FIG. 11 illustrates the improvement of hay fever symptoms of the nasal mucous membrane as a result of being treated by phototherapeutic method 200. The phototherapeutic embodiment of method 200 used visible light (400 nm-700 nm) in high doses. The severity scores of hay fever (0=no symptoms, 3=very severe symptoms) are shown before the treatment and after a 3-week treatment. The treatment included using the same dose four times per week. As shown, the clinical symptoms and complaints of the patients decreased significantly after the treatment.

[0100] Similar improvements were observed in the clinical symptoms of vasomotor rhinitis, nonallergic eosinophilic rhinitis, chronic sinusitis, and in the sizes of nasal polyps after treatment with phototherapeutical method 200. The clinical symptoms decreased considerably after the treatment.

[0101] In some embodiments the preparation of step 206 includes increasing the efficacy of phototherapeutical method 200 by administering photosensitizing substances before the phototherapy with visible light. Sometimes this method is referred to as photodynamic therapy (PDT). Example for photosensitizing substances include porphyrin precursors such as 5-aminolevulinate, or metabolites of porphyrin precursors, or other synthetic porphyrin precursors such as methyl 5-aminolevulinate. These materials can be used in concentrations between about 1% and about 20%.

[0102] In some embodiments the preparation of step 206 includes increasing the efficacy of phototherapeutical method 200 by administering a combined high intensity visible light with ultraviolet light. When a visible light is applied in combination with ultraviolet light, the minimal erythema dose (MED) can be measured on a part of the patient’s skin, which was not exposed to sunlight before starting the therapy. The MED is the smallest ultraviolet dose, which induces erythema on a previously unexposed skin after 24 hours.

[0103] In step 220 the high intensity visible light in combination with ultraviolet light is applied to the nasal mucous membrane. The application can be started with a dose about 1.0xMED to about 2.0xMED, depending on the severity of the symptoms of the patient. During repeated applications in some embodiments the dose remains approximately constant. In other embodiments the dose is increased depending on the patient’s tolerance. Step 220 can be repeated once or several times per week. Research showed that phototherapy inhibits rapidly and effectively the clinical symptoms of hay fever, including nasal blockage, nasal itch, nose running, sneezing and itching of the palate.

[0104] FIG. 12 illustrates the improvement of hay fever symptoms of the nasal mucous membrane as a result of being treated by the combined visible/ultraviolet phototherapeutic method 200. In this embodiment of the method, light source 1 is an electric discharge lamp, emitting more than 98% of its power with wavelength between about 320 nm and about 500 nm and approximately 2% of its power with wavelength between about 295 nm and 320 nm. The severity scores of hay fever (0=no symptoms, 3=very severe symptoms) are shown before the treatment and after a 3-week treatment. The treatment was applied twice per week with essentially constant doses. All the clinical symptoms and complaints of the patients decreased substantially after the phototherapy.

[0105] Similar improvements are observed in the clinical symptoms of vasomotor rhinitis, nonallergic eosinophilic rhinitis, chronic sinusitis, and the sizes of nasal polyps considerably decreased after such a combined high intensity visible light/ultraviolet phototherapy.

[0106] Phototherapeutical method 200 is also suitable for the prevention of inflammatory and hyperproliferative diseases of nasal cavities. For example, in the case of seasonal allergic rhinitis phototherapeutical method 200 can be started before the appearance of the clinical symptoms.

[0107] Similarly, phototherapeutical method 200 with photochemotherapy is also suitable for the prevention of the
clinical symptoms of patients with seasonal allergic rhinitis. The treatment can be started before the appearance of the symptoms. The treatment can be administered once or several times per week depending on the tolerance of the patient.

Finally it is noted that the application of phototherapeutic method 200 is significantly cheaper than presently practiced drug based treatments.

Potential Side Effects

When visible light is used in combination with ultraviolet light for the treatment, the ultraviolet light might facilitate the appearance of viral and bacterial infections on the treated areas because of its immunosuppressive effect. This effect is similar to the effect of topical corticosteroids. However, the likelihood for these infections is lower than that of the presently used local immuno-suppressive preparations, because light also has a direct microbicidal effect (Folwaczny M, Liesenhoff T, Lehn N, Horch H H: Bactericidal action of 308 nm excimer-laser radiation: an in vitro investigation. J Endodontics, 24: 781-785, 1998). Furthermore, light also increases the direct microbicidal activity of epithelial cells (Csanó M, Kenderessy SzA, Dobozy A: Enhancement of Candida albicans killing activity of separated human epidermal cells by ultraviolet radiation. Br J Dermatol 116: 469-475, 1987).

Practicing phototherapeutic method 200 with phototherapeutic apparatus 100 is further illustrated through the following examples.

EXAMPLE 1

Treatment of Hay Fever with High Intensity Visible Light

The severe symptoms of a patient with ragweed-induced hay fever did not respond to the antihistamine and topical corticosteroid therapy. At examination the patient complained of severe nasal blockage, nasal itching, nose running, frequent sneezing and itching of the nasal palate. Phototherapy of the nasal mucous membrane was started. For this purpose high intensity visible light of light source 1 was generated by an electric discharge lamp and the generated light beam 2 was coupled by optical focusing using concave mirror 9 into optical guidance system 4. Optical guidance system 4 was an optical cable with a diameter of 5.0 mm. The optical cable was connected to patient interface 5 shown in FIG. 2B. The treatment of the nasal mucous membrane of the patient was started with a dose of 50 J/cm². The complete time of a treatment was 15 minutes and the treatment did not cause any complaint by the patient. The treatment was then repeated three times per week using the same phototherapeutical apparatus, but the irradiation dose was increased by 20% each occasion. After the fourth treatment the symptoms and complaints of the patient decreased to a large extent and in the third week after the nine treatment the patient was completely free of symptoms. The treatment was stopped and no recurrence was observed. The patient found this type of therapy to be more efficacious as compared to the previously used therapies.

EXAMPLE 2

Treatment of Hay Fever with a Combination of High Intensity Visible Light and Ultraviolet Light

A patient with severe hay fever due to ragweed allergy did not improve under conventional therapy with antihistamines and corticosteroids. Therefore, an embodiment of phototherapeutical method 200 was administered. A special light source 1 was used to generate ultraviolet and high intensity visible light. The intensity of the light at the output end of patient interface 5 was 700 mW/cm². The UVB (300-320 nm wavelengths) content of light beam 2 was 1%, the UVA (320 nm-400 nm) content was 13%, and the remaining 84% was in the visible (400-650 nm) portion of the spectrum. The minimal erythema dosage (MED) was first determined on the forearm of the patient not exposed to sunlight earlier, then a phototherapeutical treatment of the nasal mucous membrane was started with a dose of 1xMED. The patient interface 5 shown in FIG. 2B was brought into contact with the mucous membrane and this surface was irradiated during the treatment. The treatment was controlled visually under protection of ultraviolet protecting eyeglasses. This phototherapy was repeated three times per week. After the sixth treatment the symptoms of the patient decreased considerably, and after the eighth treatment the patient became free of symptoms. One month after stopping the therapy the patient was still free of symptoms.

EXAMPLE 3

Treatment of Hay Fever with Photodynamic Therapy

The clinical symptoms of a patient suffering from ragweed-induced hay fever did not respond satisfactorily after using antihistamines and topical corticosteroid nasal drops. At examination the symptoms (nasal blockage, nasal itching, nose running, frequent sneezing and itching of the nasal palate) of the patient were severe, therefore an embodiment of a photodynamic therapy was performed. The nasal mucosa was treated with 20% 5-deltaaminoleval¹nic acid (DALA) lotion 3 hours before phototherapy. For the phototherapy, light source 1 of the type shown in FIG. 2B was used, generating light with wavelengths between 300 nm and 700 nm. The ultraviolet part of the generated light was filtered out by choosing a non-ultraviolet-transmissive optical guidance system 4. The treatment of the nasal mucous membrane was started with a dose of 20 J/cm² using patient interface 5 shown in FIG. 2B. Photodynamic therapy was then repeated twice weekly. Patient interface 5 was brought into contact with the nasal mucous membrane altogether in eight positions in each nostril. The treatment of the nostrils took approximately 10 minutes. The symptoms of the patient improved considerably after the second treatment and after two weeks the patient was completely free of symptoms. After stopping the therapy the symptoms of the patient did not return.

EXAMPLE 4

Treatment of Nasal Polips with Photodynamic Therapy

A patient had a large polyp in the right nostril, that has been operated already several times. The patient had also severe perennial rhinosinusitis, possibly inducing the recur-
rence. A 20% DALA solution was applied to the nasal polip. Three hours thereafter visible light phototherapy using light source 1 was used to generate and deliver high intensity visible light to the affected area. Light source 1 of the type shown in FIG. 2B was used, generating light with wavelengths between 300 and 700 nm. The ultraviolet part of the emitted spectrum was filtered out by choosing a non-UV-transmissive optical guidance system. The treatment of the nasal mucous membrane was started with a dose of 60 J/cm² using patient interface 5 shown in FIG. 2B. Five days after one single treatment the nasal polyp disappeared without any scar formation. The photodynamic therapy was then repeated once weekly for 8 weeks. After stopping the therapy the nasal polyp did not return. All complaints of the patient disappeared as well.

[0120] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions, and alterations can be made therein without departing from the spirit and scope of the invention as defined by the appended claims. That is, the discussion included in this application is intended to serve as a basic description. It should be understood that the specific discussion may not explicitly describe all embodiments possible; many alternatives are implicit. It also may not fully explain the generic nature of the invention and may not explicitly show how each feature or element can actually be representative of a broader function or of a great variety of alternative or equivalent elements. Again, these are implicitly included in this disclosure. Where the invention is described in device-oriented terminology, each element of the device implicitly performs a function. Neither the description nor the terminology is intended to limit the scope of the claims.

What is claimed is:

1. A phototherapeutical apparatus, comprising:
   a light source, operable to generate high intensity, visible light;
   an optical guidance system, operable to receive and guide the light of the light source; and
   a patient interface, operable to receive the guided light from the optical guidance system; and
   to apply the guided light to a tissue surface of a nasal cavity.

2. The phototherapeutical apparatus of claim 1, wherein the patient interface is insertable at least partially into the nasal cavity.

3. The phototherapeutical apparatus of claim 1, wherein the light source is capable of generating a combination of visible and ultraviolet light with wavelengths in the range of about 280 nm to about 700 nm.

4. The phototherapeutical apparatus of claim 1, wherein the light source is capable of generating a combination of visible and ultraviolet light with wavelengths in the range of about 280 nm to about 600 nm.

5. The phototherapeutical apparatus of claim 1, wherein high intensity light comprises light with a dose between about 10 J/cm² and about 100 J/cm².

6. The phototherapeutical apparatus of claim 1, wherein the light source is one of an essentially monochromatic light source and a multifrequency light source.

7. The phototherapeutical apparatus of claim 6, wherein the light source is one of a laser, a fluorescent lamp, a light emitting diode, a dye laser, an arc lamp, and an electric discharge lamp, the electric discharge lamp comprising at least one of xenon, argon, and mercury vapor.

8. The phototherapeutical apparatus of claim 6, wherein the multifrequency light source comprises:
   a quartz bulb, capable of generating an arc with a length between about 1 mm and about 10 mm.

9. The phototherapeutical apparatus of claim 1, wherein the phototherapeutical apparatus comprises:
   a concave mirror, reflecting a portion of the generated light;
   a focusing lens, operable to focus a portion of the generated light and a portion of the reflected light;
   an optical filter, operable to receive and filter the focused light; and
   a beam shutter, operable to control the generated light.

10. The phototherapeutical apparatus of claim 1, wherein the optical guidance system comprises at least one of:
   an optical cable, having a diameter between about 1 micron and about 10 mm and comprising quartz glass fiber; and
   an optical arm, comprising at least one capillary tube, wherein the tube contains an light conducting fluid, and wherein the internal surfaces of the tube are at least partially covered with an light reflecting coating.

11. The phototherapeutical apparatus of claim 1 wherein the phototherapeutical apparatus is applicable for at least one of the treatment and the prevention of inflammatory and hyperproliferative diseases, comprising:
   allergic rhinitis, rhinotis, vasomotor rhinitis, non-allergic cosinophilic rhinitis, chronic sinusitus, and diseases of mucous membranes of the gastrointestinal and urogenital systems.

12. A method of treating diseases, the method comprising:
   providing a phototherapeutical apparatus, comprising:
   a light source, capable of generating high intensity visible light;
   an optical guidance system, coupled to the light source; and
   a patient interface, coupled to the optical guidance system;
   preparing for the application of the phototherapeutical apparatus;
   generating high intensity visible light with the light source;
   coupling the high intensity visible light into the patient interface through the optical guidance system; and
applying the high intensity visible light by the patient interface to a tissue surface of a nasal cavity, wherein the tissue of the nasal cavity has at least one of an inflammatory disease and a hyper-proliferative disease.

13. The method of claim 12, wherein the applying the light by the patient interface comprises:

inserting the patient interface at least partially into the nasal cavity.

14. The method of claim 12, wherein the light source is capable of generating a combination of visible light and ultraviolet light, with wavelengths in the range of about 280 nm to about 700 nm.

15. The method of claim 12, wherein the light source is capable of generating a combination of visible light and ultraviolet light, with wavelengths in the range of about 280 nm to about 600 nm.

16. The method of claim 12, wherein the applying the light comprises

applying the high intensity visible light with a dose between about 10 J/cm² and about 100 J/cm².

17. The method of claim 12, wherein the light source is a porphyrin precursor, a metabolite of a porphyrin precursor, and a synthetic photosensitizing compound, wherein the photosensitizer substance becomes activated after the application of the generated light.

18. The method of claim 12, wherein the light source is one of a laser, a fluorescent lamp, a light emitting diode, a dye laser, an arc lamp, and an electric discharge lamp, the electric discharge lamp comprising at least one of xenon, argon, and mercury vapor.

19. The method of claim 12, wherein the light source generates a quasi-continuous light with a frequency less than about 100 Hertz.

20. The method of claim 12, wherein the inflammatory disease is at least one of allergic rhinitis, vasomotor rhinitis, non-allergic rhinitis, rhinosinusitis, sinusitis, and nasal polyp.

21. The method of claim 12, wherein the preparation for the application of the phototherapeutical apparatus comprises determining at least one of a minimal erythema dose.

22. The method of claim 21, wherein the applying the light to the tissue surface of the body cavity comprises

applying the light in a dose calculated in relation to at least one of the minimal erythema dose.

23. The method of claim 12, wherein the preparation for the application of the phototherapeutical apparatus comprises

applying a photosensitizer substance to the tissue surface.

24. The method of claim 23, wherein the photosensitizer substance is at least one of a porphyrin precursor, a metabolite of a porphyrin precursor, and a synthetic photosensitizing compound, wherein the photosensitizer substance becomes activated after the application of the generated light.

25. The method of claim 23, wherein the applying the photosensitizer substance comprises

applying the photosensitizer substance to the tissue surface in a concentration between about 1% and about 20%.

26. A method of preventing diseases, the method comprising:

providing a phototherapeutical apparatus, comprising:

- a light source, operable to generate high intensity visible light;
- an optical guidance system, coupled to the light source; and
- a patient interface, coupled to the optical guidance system;

preparing for the application of the phototherapeutical apparatus;

generating high intensity visible light with the light source;

coupling the high intensity visible light into the patient interface through the optical guidance system;

applying the high intensity visible light by the patient interface to a tissue surface of a nasal cavity, wherein the tissue of the nasal cavity is symptom-free.

27. The method of claim 26, wherein the applying the light by the patient interface comprises

inserting the patient interface at least partially into the nasal cavity.

28. The method of claim 26, wherein the preventing diseases comprises

preventing at least one of an inflammatory disease and a hyper-proliferative disease.

29. The method of claim 26, wherein the preventing diseases comprises

preventing a disease of at least one of a mucous membrane of a nasal cavity and a nasal sinus.