

APPARATUS FOR RETINA PHOTOTHERAPY

DESCRIPTION

BACKGROUND OF THE INVENTION

[Para 1] The present invention is generally directed to a system for reliably and comfortably providing retina treatment to patients. More particularly, this invention is directed to a system able to accommodate patients of various shapes and sizes in a comfortable manner and more effectively target and treat patient's retinas.

[Para 2] Prior art systems and devices were not comfortable for patients to use and were inefficient at targeting and treating patient's retinas. Such prior art systems presented cramped or close quarters for patients to squeeze or jam themselves into. Such could cause pain or discomfort for the patient. In certain instances, it may also result in injury if the patient cannot maintain the position or falls out of position either to the floor or into a piece of furniture or equipment.

[Para 3] In such uncomfortable positions, it was difficult for a patient to remain sufficiently immobile long enough for a treatment cycle to complete. Treatment would be prolonged or restarted for multiple cycles if the patient moved during the treatment.

[Para 4] Thus, there is a need for a system and/or device that provide a more comfortable treatment position for a patient and more reliably and efficiently

provides treatment to a patient's retina. The present invention fulfills these needs and provides other related advantages.

SUMMARY OF THE INVENTION

[Para 5] The present invention is directed to an apparatus for retina phototherapy. The apparatus includes a retina phototherapy device adjustably associated with a headrest assembly. The retina phototherapy device comprises a radiant energy source, including but not limited to a laser, and projection optics, are oriented generally toward the headrest assembly and configurable so as to target a retina of a person using the headrest assembly. It also includes a camera oriented generally toward the headrest assembly and configurable so as to focus on and capture an image of the retina of the person using the headrest assembly. A monitor, possibly a flat screen, is associated with the camera and the radiant energy source and projection optics and is configurable so as to display the image of the retina being targeted. A base on the retina phototherapy device is configured for micro-adjustment of a position of the retina phototherapy device in a three-dimensional coordinate space in relation to the headrest assembly.

[Para 6] The apparatus may also include a substantially horizontal working surface upon which the retina phototherapy device is adjustably disposed. The height of the working surface is preferably adjustable in a vertical direction and the headrest assembly fixedly extends from a leading edge of the working surface. The headrest assembly comprises a forehead rest and a chin rest that

are both height adjustable relative to the working surface. The base of the retina phototherapy device may include a control joystick for micro-adjusting the position of the retina phototherapy device across the working surface in the three-dimensional coordinate space. The position of the retina phototherapy device is macro-adjustable across the working surface in a two-dimensional coordinate space by manual movement of the base.

[Para 7] The camera is may be an infrared camera configured to capture an infrared image of the retina. Preferably, the camera, radiant energy source, and projection optics are coaxially disposed and oriented in the same direction. The control joystick may also be operatively connected to the laser projection optics and the camera, with the control joystick being configured so as to focus the camera and activate the radiant energy source.

[Para 8] Other features and advantages of the present invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 9] The accompanying drawings illustrate the invention. In such drawings:

[Para 10] FIGURE 1 is a perspective view of the retina phototherapy system of the present invention;

[Para 11] FIGURE 2 is a top view of the retina phototherapy system of the present invention;

[Para 12] FIGURE 3 is a back view of the retina phototherapy system of the present invention;

[Para 13] FIGURE 4 is a front view of the retina phototherapy system of the present invention;

[Para 14] FIGURE 5 is a side view of the retina phototherapy system of the present invention;

[Para 15] FIGURE 6 is an elevated rear view of the retina phototherapy system being used on a right eye of a patient;

[Para 16] FIGURE 7 is an elevated rear view of the retina phototherapy system being used on a left eye of a patient; and

[Para 17] FIGURE 8 is a block diagram of the configuration of the camera and laser optics.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[Para 18] The present invention is generally directed to a system for treating a patient's retina with a radiant energy source, including but not limited to a laser. Throughout this description the use of "laser" on its own or as part of a larger assembly shall include any radiant energy source. The system, generally referred to by reference numeral 10 in FIGS. 1-7, consists primarily of a working surface 12 and a retina phototherapy device 14. The following description will refer to the relative position of various components in a 3-

dimensional coordinate system, i.e., X, Y, and Z axes. Under this convention, the X-axis refers to lateral or side-to-side movement relative to the horizontal. The Y-axis refers to longitudinal or front-to-back movement relative to the horizontal. The Z-axis refers to vertical or up-and-down movement relative to the horizontal.

[Para 19] As illustrated in FIGS 1-5, the working surface 12 is a generally horizontal, planar surface that rests on legs 16 or similar supports. The height of the legs 16 is preferably adjustable such that the position of the working surface 12 in the Z-axis is adjustable on a macro scale, i.e., units of feet or inches. The legs 16 may rest on the floor using pads or wheels (not shown), such that the legs are either stationary or moveable relative to the floor.

[Para 20] A headrest assembly 18 extends from the top of the working surface 12. A pair of base arms 20 are affixed to the top of the working surface in a generally parallel configuration in the longitudinal direction, i.e., along the Y-axis. Curved extension arms 22 are attached to the base arms 20 proximate to a leading edge 12a of the working surface 12. The curved extension arms 22 rise upward above the working surface 12 and extend forward of the leading edge 12a. A pair of uprights 24 extends vertically through a distal end of the extension arms 22, wherein the height of the uprights 24 relative to the working surface 12 is adjustable.

[Para 21] A chin rest 26 extends between a lower end of the uprights 22 and a forehead rest 28 extends between upper ends of the uprights 22. The chin rest 26 and forehead rest 28 are respectively configured to receive the chin and

forehead of a person's face. An adjustment coupling 30 on the uprights 22 allows for the spacing of the chin rest 26 and forehead rest 28 to be adjustable relative to each other so as to accommodate faces of different sizes. As described above, the curved extension arms 22 rise above (in the direction of the Z-axis) and forward of (in the direction of the Y-axis) the working surface 12 so as to position the face of a person in front of the retina phototherapy device 14 as further described below.

[Para 22] The retina phototherapy device 14 generally resembles a self-standing, gun-like device having a flat base pad 32, a vertical stand 34, and a projecting barrel 36. A radiant energy source and projection optics 38, i.e., laser optics, extend from a distal end of the barrel 36. The laser optics 38 are preferably wide angle optics having a range of 110 degrees or greater (See FIG. 8). A display monitor or viewing screen 40 is disposed on a proximate end of the device 14, preferably proximate to the junction of the vertical stand 34 and the barrel 36. The base pad 32 rests on the top of the working surface 12 and is sufficiently large to provide a stable base for the device 14. The device 14 preferably has a unitized construction design as illustrated, wherein all components are contained within a housing. The housing of the device 14 preferably has a high-gloss, opalescent finish, and seams/modular junctions of a high tolerance, i.e., close fitting or low profile, for an aesthetically pleasing appearance. The high tolerance seams/modular junctions also prevent dust entry and dirt accumulation. The system 10 preferably has a modular construction such that its various components – working surface 12, device 14,

and headrest assembly 18 – may be easily removed and replaced in a short amount of time without substantial downtime. A defective or broken component may be easily removed and replaced with another component this is shipped overnight, for example.

[Para 23] A joystick 42 having a spherical contact junction provides multiple degrees of movement to control operation of the device 14. Multiple degrees of movement refers to movement in directions such as, front-to-back, side-to-side, up and down (z-axis adjustment), and clockwise/counterclockwise rotation. Certain of these degrees of movement of the joystick 42 are configurable to control movement of the device 14 across the working surface, particularly micro-movements, in the X, Y, and Z axes, as well as, rotation in the horizontal X-Y plane. Others degrees of movement of the joystick 42 may also control focus of the laser optics 38 or a camera as described below. The joystick 42 may also have a button or switch 44 to begin treatment delivery for the laser optics 38 or device 14 overall.

[Para 24] The display/monitor 40 is connected to a camera 46, preferably IR but also capable of capturing visible light spectrums. The camera 46 is preferably disposed adjacent to or coaxially with the laser optics 38 such that both components focus on the same target. The joystick 42 may be configured to control the focus of the camera 46 or alter the type of lens being used or light wavelengths to be detected. The image projected on the display/monitor 40 by the camera 46 permits a user to observe exactly where the laser optics 38 are pointed, particularly when treating a patient's retina. The display/screen

40 preferably presents a hi-resolution image of the patient's retina from the camera 46. The camera 46 preferably includes a fixed or parfocal lens such that it can be used as a range finder and generally stays in focus when the magnification/focal length is changed. The camera 46 may be associated with a light source (not shown), as a ring or adjacent light. The light source is preferably an infrared (IR) light source to provide illumination for the camera 46 and avoid pupil constriction.

[Para 25] An LCD aperture (not shown) to shape or partially occlude the opening for the laser optics 38 is preferably associated with the laser optics 38. The monitor 40 preferably has touch screen functionality to allow for finger tracing selection of treatment subfields via the LCD aperture. Treatment subfields may be determined based upon automatic identification of different retina structures, i.e., optic nerve, to as to exclude these areas from treatment. The excluded areas may be used as a tracking or stabilization target.

[Para 26] The laser optics 38 and camera 46 preferably include auto focus and range finder features. The laser optics 38 and camera 46 preferably also include image and laser projection stabilization, tracking, and registration features. Optical correction circuitry may be included to achieve laser optics 38 and camera 46 image par focus. The device 14 also includes an electronic memory to record fundus images and transfer procedure information, i.e., completion of prescribed treatment, into patient records. Such information would preferably include name, treatment date, treatment areas, date of birth, patient identification number, etc.

[Para 27] The device 14 may also include a secure communication protocol, i.e., Wi-Fi, Bluetooth, cellular, or satellite, or similar connection 48 to wirelessly transmit the procedure information. The same information may be wirelessly transmitted to a billing department to execute billing upon completion of treatment. The same wireless connection 48 or a comparable wired connection port, i.e., USB or similar, can allow for the uploading or reconfiguring of laser parameters and accompanying software. The operator or doctor may also use this wireless connection 48 to input patient information via a laptop or electronic medical record system prior to treatment. These same communication protocol functions may also be performed using a wired connection, i.e., USB or Ethernet.

[Para 28] For movement of the device 14 across the working surface, there are generally two types of movement – macro-movement and micro-movement – both in the plane of the working surface 12 and vertically above the working surface 12. Macro-movement refers to movement of the device 14 across the working surface on an easily observable scale, i.e., in terms of inches, centimeters, or other similar distance, between the two base arms 20. Micro-movement refers to fine-tune positioning of the device 14 in relation to a person's retina. Such fine-tune positioning or micro-movement is accomplished through use of the joystick 44 as described above. The joystick controls position motors or other mechanisms (not shown) on the underside of the base 32.

[Para 29] FIGS. 6 and 7 illustrate a person positioned in the headrest assembly 18, with their chin in the chin rest 26 and forehead in the forehead rest 28. The ergonomic configuration of the extension arms 22 in the headrest assembly 18 and the barrel 36 of the device 14 are designed to accommodate any type of head, body, or face by effectively reaching out to the patient rather than having the patient “jam” into the device. Patients with deep-set eyes, prominent brows, large chests, overweight, very tall, or very short can all be accommodated with this configuration.

[Para 30] The device 14 is preferably manually moved across the working surface 12 – macro-movement – to generally align the laser optics 38 and camera 46 with the eye. The contact surfaces of the working surface 12 and the underside of the base 32 are preferably very low friction surfaces to facilitate the manual movement. A high friction plate (not shown) may be triggered to prevent further macro-movement once the device 14 is positioned. A visible patient fixation target or general positioning light (not shown) configured to illuminate the target area may be included to assist with this general alignment. The positioning light is projected into the eye coaxially with the laser optics 38 and camera 46. One may then use the joystick 42 and position motors to fine-tune the position and precise alignment of the device laser optics 38 and camera 46 with the eye.

[Para 31] In use, the operator brings the patient eye into view on the monitor 40 through the camera 46 and fine focuses using the degrees of movement of the joystick 42. The camera 46 projects an image of the retina in the back of

the eye on the monitor 40. The monitor 40 or image projected by the camera 46 may include guide markings or a grid (not shown) to help accurately position the laser optics 38 in line with the eye and retina.

[Para 32] Once the retina is in fine focus and the treatment area is marked, the operator begins the treatment. Treatment is automatic until completed, even if occasionally interrupted by patient movement. The device 14 may capture multiple static images and/or videos of the patient's retina before, during and after treatment. The completion and thoroughness of treatment are preferably documented by retinal reflectance detected and recorded by the retinal fundus monitoring camera 46.

[Para 33] FIGURE 8 schematically illustrates a preferred configuration of the camera 46 and laser optics 38 in more detail. In this configuration, the camera 46 is aligned directly with the patient's retina 54 as shown. The radiant energy source 50 is shown offset from the camera 46 with its beam redirected by a steering mirror 56. The steering mirror reflects the radiant energy beam to a beam splitter 58. The beam splitter 58 is preferably of a reversed configuration so as to combine the reflected beams from the steering mirror 56. The beam splitter redirects the combined radiant energy beam through a lens 52 which focuses the same on the retina 54 in the back of the patient's eyeball. As illustrated, the radiant energy beam preferably has a target area range of about one hundred degrees around the curvature of the retina. The preferred distance between the laser optics 38 and the patient's eye is at least one centimeter. In order to project a beam in a spot that is large enough on the

retina through the pupil, the beam must be focused through a point between the final optics or lens 52 and the pupil. This assumes a minimum pupil diameter of about five millimeters in the desired treatment lighting. These distances are just preferred ranges and other distances may work as intended with different configurations of energy sources 50, lenses 52, steering mirrors 56, and beam splitters 58. The camera 46 preferably operates through or around the lens 52 and beam splitter 58 without interfering with the path of the radiant energy beam.

[Para 34] Although several embodiments have been described in detail for purposes of illustration, various modifications may be made without departing from the scope and spirit of the invention. Accordingly, the invention is not to be limited, except as by the appended claims.

What is claimed is:

[Claim 1] An apparatus for retina phototherapy, comprising:

a retina phototherapy device adjustably associated with a headrest assembly, the retina phototherapy device comprising:

a radiant energy source and projection optics oriented generally toward the headrest assembly and configurable so as to target a retina of a person using the headrest assembly;

a camera oriented generally toward the headrest assembly and configurable so as to focus on and capture an image of the retina of the person using the headrest assembly;

a monitor associated with the camera configurable so as to display the image of the retina being targeted by the radiant energy source and projection optics; and

a base configured for micro-adjustment of a position of the retina phototherapy device in a three-dimensional coordinate space in relation to the headrest assembly.

[Claim 2] The apparatus for retina phototherapy of claim 1, further comprising a substantially horizontal working surface upon which the retina phototherapy device is adjustably disposed, wherein the headrest assembly fixedly extends from a leading edge of the working surface.

[Claim 3] The apparatus for retina phototherapy of claim 2, wherein the headrest assembly comprises a forehead rest and a chin rest that are both height adjustable relative to the working surface.

[Claim 4] The apparatus for retina phototherapy of claim 2, further comprising a control joystick on the base of the retina phototherapy device, wherein the control joystick micro-adjusts the position of the retina phototherapy device across the working surface in the three-dimensional coordinate space.

[Claim 5] The apparatus for retina phototherapy of claim 2, wherein the position of the retina phototherapy device is macro-adjustable across the working surface in a two-dimensional coordinate space by manual movement of the base.

[Claim 6] The apparatus for retina phototherapy of claim 1, wherein the camera is an infrared camera configured to capture an infrared image of the retina.

[Claim 7] The apparatus for retina phototherapy of claim 1, wherein the camera, radiant energy source and projection optics are coaxially disposed and oriented in the same direction.

[Claim 8] The apparatus for retina phototherapy of claim 4, wherein the control joystick is operatively connected to the radiant energy source and the camera, the control joystick configured so as to focus the camera and activate the radiant energy source.

[Claim 9] The apparatus for retina phototherapy of claim 2, wherein a height of the working surface is adjustable in a vertical direction.

[Claim 10] An apparatus for retina phototherapy, comprising:

- a substantially horizontal working surface having a headrest assembly fixedly extending from a leading edge thereof;

- a retina phototherapy device adjustably disposed on the working surface, the retina phototherapy device comprising:

- a radiant energy source and projection optics oriented generally toward the headrest assembly and configurable so as to target a retina of a person using the headrest assembly;

- a camera coaxially disposed with the radiant energy source and projection optics, and oriented in the same direction generally toward the headrest assembly, the camera configurable so as to focus on and capture an image of the retina of the person using the headrest assembly;

- a monitor associated with the camera, the radiant energy source, and projection optics configurable so as to display the image of the retina being targeted by the radiant energy source and projection optics; and

a base configured for micro-adjustment of a position of the retina phototherapy device across the working surface in a three-dimensional coordinate space.

[Claim 11] The apparatus for retina phototherapy of claim 10, wherein the headrest assembly comprises a forehead rest and a chin rest that are both height adjustable relative to the working surface.

[Claim 12] The apparatus for retina phototherapy of claim 10, further comprising a control joystick on the base on the base of the retina phototherapy device, wherein the control joystick micro-adjusts the position of the retina phototherapy device across the working surface in the three-dimensional coordinate space.

[Claim 13] The apparatus for retina phototherapy of claim 10, wherein the position of the retina phototherapy device is macro-adjustable across the working surface in a two-dimensional coordinate space by manual movement of the base.

[Claim 14] The apparatus for retina phototherapy of claim 10, wherein the camera is an infrared camera configured to capture an infrared image of the retina.

[Claim 15] The apparatus for retina phototherapy of claim 12, wherein the control joystick is operatively connected to the radiant energy source and the camera, the control joystick configured so as to focus the camera and activate the radiant energy source.

[Claim 16] The apparatus for retina phototherapy of claim 10, wherein a height of the working surface is adjustable in a vertical direction.

[Claim 17] An apparatus for retina phototherapy, comprising:

- a substantially horizontal working surface having a headrest assembly fixedly extending from a leading edge thereof, wherein a height of the working surface is adjustable in a vertical direction;

- a retina phototherapy device adjustably disposed on the working surface, the retina phototherapy device comprising:

- a radiant energy source and projection optics oriented generally toward the headrest assembly and configurable so as to target a retina of a person using the headrest assembly;

- an infrared camera coaxially disposed with the radiant energy source and projection optics, and oriented in the same direction generally toward the headrest assembly, the camera configurable so as to focus on and capture an infrared image of the retina of the person using the headrest assembly;

a monitor associated with the camera, the radiant energy source, and projection optics configurable so as to display the image of the retina being targeted by the radiant energy source and projection optics; and

a base configured for macro-adjustment of a position of the retina phototherapy device across the working surface in a two-dimensional coordinate space by manual movement and micro-adjustment of a position of the retina phototherapy device across the working surface in a three-dimensional coordinate space by a control joystick.

[Claim 18] The apparatus for retina phototherapy of claim 17, wherein the headrest assembly comprises a forehead rest and a chin rest that are both height adjustable relative to the working surface.

[Claim 19] The apparatus for retina phototherapy of claim 17, wherein the control joystick is operatively connected to the radiant energy source and the camera, the control joystick configured so as to focus the camera and activate the radiant energy source.