How Can Light Penetrate to the Brain?

Hair, skin, bone, cerebral spinal fluid, and dura. Light has to pass through all of this to reach the brain. Can photobiomodulation devices penetrate the obstacles to reach the target? Proper transcranial and intranasal devices do deliver therapeutic levels of light to the brain. In addition, the technique of "remote" photobiomodulation treats the blood, which then delivers energized mitochondria to the brain.

Studies on live human heads, quasi-human heads, and cadaver human heads have all yielded therapeutic dose results. Up to ten percent of infrared light passes through the scalp and reaches up to 5 cm deep into the brain. Hair can interfere with delivery but has not presented a problem in major studies. Older patients do tend to have thinner (or no) hair. Maybe elderly hair tends to expose the scalp more. In at least two cases, researchers used water to keep hair out of the way.

More power does not mean more penetration. Powerful light sources have greater reflection off the scalp than lower-energy light. It turns out that the light's wavelength has a greater effect on penetration depth than power. A 660 nm light reaches the top of the brain. An 810 nm light reaches deeper, and a 1064 nm light reaches the deepest of the three. Note that LED devices output a range of wavelengths with their nominal value being the peak. Mitochondria absorb light in ranges. The values do not need to be exact to have a good effect.

A Review of Light Penetration

In a review of the literature on light penetration through the head, researchers reported on light to the heads of mice, a rat, a rabbit, a pig, and a human. Again, infrared delivered more photons than red light. Laser light did penetrate farther than LED light. Thin tissue allowed photons to travel farther into the skull than thick tissue. The animal penetration depths ranged from 0.11% to 70.9%. Light delivered to human heads delivered 0.2% to 10% of the total output.

The Neurosurgery Studies

Animal studies on light penetration do not extrapolate well to human heads. An accurate measurement requires placing a photosensitive plate onto the actual brain, but who would agree to that operation? It turns out, people who were having brain surgery anyway would agree to that request. Researchers attended multiple operations. At each one, the surgeon burrowed a hole into the scalp, and then researchers placed a photodetector on the brain. They measured how much light passed through the skin, bone, dura, and cerebral spinal fluid. On average, infrared light penetrated 3cm to 5 cm into the matter. Six to ten percent of the light made it from the exterior to the brain. The study found that infrared photons would stimulate 80% of the pyramidal neurons. Pyramidal nerve cell loss correlates with Alzheimer's severity.

The Orbicularis Oris Study

One way to test for penetration is through the orbicularis oris (OO). This is the muscle below the nose, but above the lip. Researchers put photosensitive plates in the mouths of two subjects. They received light through that area above the lip. The longest distance from the light to the photosensitive plate was 9.8 mm (just short of a centimeter, or 1/3 of an inch). They tested 10 mW, 20 mW, and 30 mW power. The infrared light delivered with 30 mW delivered the highest amount of photons.

The Eight Cadaver Heads Study

If you cannot find brain surgery patients, you could try measuring light into a cadaver head. One group of researchers tested low energy laser light on eight human cadaver heads. 10 Hz and 100 Hz pulsing did not change the results. Red light reached .29 cm into the brain. Infrared reached 0.22 cm and 0.47 cm.

The Parkinson's Penetration Study

Using another cadaver head, Parkinson's researchers tested how far light traveled up the nose to the brain. After thawing their cadaver, they separated her head from her body. They took MRI images and CT scans to map where the photoreceptors should go. Parkinson's affects the substantia nigra, which is where they pointed the light. 0.36% of the infrared and 0.03% of the red light reached the target.

The Visible Chinese Human Head Study

Back in 2002, carbon monoxide killed a young man in Chongqing, China. The "people of Chongqing" donated his body to the Visible

Chinese Human project. They replaced his blood with gelatin and formaldehyde, but kept the tissues intact. Then they cryosectioned (sliced) him into 3,640 pieces. They took MRIs and photographs of each section. It took six months of labor in a - 25 C laboratory. Then they digitized the pictures using three-dimensional software. His pictures became the High Precision Visible Chinese Human. . In 2011, another set of researchers used the digital head in a series of photobiomodulation penetration experiments. Of the red and infrareds they tested at 10, 20 and 30 mW, the 810 nm wavelength at 30 mW had the greatest penetration. The virtual light reached through the white matter and into the gray with 8% of the total light.

The Infrared Imaging Study

Another option to study penetration is to compare infrared imaging to a known quantity such as MRI images. In a study testing the viability of near infrared spectroscopy (NIRS) imaging technology, researchers mapped a subject's brain with infrared and with a traditional MRI. Upon comparing the images from each device, they concluded the NIRS is a viable alternative to MRI. The infrared light passed through hair, skin, skull, dura, and cerebral spinal fluid. It reached as far as 1.4 cm into the brain's white matter.