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Artificial Retinas Restore Sight to Blind

ARTIFICIAL VISION, ARTIFICIAL RETINA

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Welcome to the Revealing Retina presented by the American Retina Foundation, the charitable arm of the ASRS. The American Society of Retina Specialists. I am your host Dr. Roy Levitt, chairman of the American Retina Foundation and joining me today is Dr. Mark Humayun.

DR. ROY LEVITT:

Hello Mark

DR. MARK HUMAYUN:

Hi Roy, thank you for having me on the show.

DR. ROY LEVITT:

It is my pleasure.

Dr. Humayun is a vitreoretinal surgeon. He is at the Doheny Eye Institute at the Keck School of Medicine at USC where he is professor of Ophthalmology, professor of Biomedical Engineering, and Cell Neurobiology. He did his training at Duke and at Wilmer and currently had some interesting positions. He is the director of the National Science Foundation, The Biomimetic Microelectronic Systems Engineering Research Center and I will let to explain that Mark and he is also director of the Department Of Energy, the Artificial Retina Project, which is unique consortium of 5 Department with Energy Laboratories, 5 universities as well as industry.

Mark as you and I both know from what is all about ophthalmic history, the possibility of some form of artificial vision was a stuff of fantasy. Every year in my practice I had patients who would ask about eye transplants or artificial eyes and I would try to explain how difficult if not impossible would be to connect 1.5 million nerve fibers in the optic nerve. The technology has changed the playing field and I would like for you to give us a brief history of how this Artificial Retina Research you are engaged in came about.

DR. MARK HUMAYUN:

Well, I will be happy to Roy. It is indeed something that is very exciting. It is the ability to use State-of-the-Art Microelectronics to restore sight to those who are completely blind and I will explain it is not for all types of blindness, but it is a large subset of patients who are blind especially from retinal conditions. Currently, the way the device works is we use a tiny little lightweight camera, which is worn

in the glasses and you cannot even tell that the subject is wearing this or the patient is wearing this device. The camera picks up images in the environment and then sends this wirelessly to a chip that is implanted around or in the eye. This chip then receives this information, decodes it, and in accord with proprietary software, which we have developed ends up stimulating the nerve cells of the eye and sends the information to the brain. So, effectively you are taking somebody who is blind and hooking them up to a camera to be able to see. Now the type of blindness that this does work with that we have tested are inherited retinal conditions like retinitis pigmentosa. So, this is an inherited condition, which occurs in 1 in 4000 and results in damaging the rods and cones of the light-sensing cells of the retina and so what we are doing with the chip is basically bypassing those damaged light detectors and jump-starting the remaining nerve cells in the eye and sending the information to the brain. So that is how this works and if we are widely successful when we get the resolution and imagery we get then, again we hope to go beyond putting them in people who are completely blind to those who are visually impaired, but right now their device is being put in under an FDA trial only in patients who have retinitis pigmentosa, this inherited condition and who are completely blind.

DR. ROY LEVITT:

This prosthesis really works in a situation in which the optic nerve and some of the visual cells or at least the nerves in the retina are still functioning.

DR. MARK HUMAYUN:

Correct that what you need is not all of the optic nerve. We found about 30% of the optic nerve you do need, you need some connection from the eye to the brain and what the chip does is jump-start the nerve cells in the eye and these remaining fibers then connect that information and pass along to the brain.

DR. ROY LEVITT:

And when you implant this chip, where is it placed?

DR. MARK HUMAYUN:

This particular chip is called the Argus series and it is the company that makes Second Sight Medical Products and the Argus II chip, which is one that is an international trials as well as nationally. So it is in about 4 centers in the United States and 4 internationally. This particular chip is placed in and around the eye, but the key thing is that the chip in the electronics never touch the delicate tissue of the retina and therefore none of the heat, none of the sharpness of the chip, or any of those aspects are transmitted to the retina so it is in and around the eye, but what touches the retina is a very delicate set of wires that are much like a Band-Aid and so these Band-Aids are very delicate, it is a strand wrap type wire that actually delicately touch the retina and it is through these wires that current is passed to the retina, so the key is the chip is in and around the eye, but it never touches the retina, only this is a very delicate Band-Aid type wires that are strand wrap like wires do touch the retina.

DR. ROY LEVITT:

Ands it is placed not through the retina but through the sclera.

DR. MARK HUMAYUN:

Yes, so the little cable of wires is placed through the eye wall, which is the sclera and then put delicately on the surface of the retina where some of the nerve cells are, the ganglion cells, and by laying them right on top of these nerve cells, the electric current then jump-starts these nerve cells in accord with the type of patterns of stimulation that are being delivered to these electrodes and this device. So, each electrode when it stimulates, creates a spot of light. So, imagine a group of electrodes can create a dot of light much like on a scoreboard and are much like a pixelized vision like pixels in a camera. So by those together actually you come up with the entire image.

DR. ROY LEVITT:

So far the patients who have had this prosthesis, what are they able to see?

DR. MARK HUMAYUN:

What the patients are able to see, these people have been blind, completely blind, no light perception, cannot see the brightest light, or can barely see a photographic flash, and even that very inconsistently, and they have been blind for 20, 30, and even 50 years, so half a century, and what they are able to see initially is just spots of light where the electrodes are stimulating and it turns out that there is a very interesting story to be told and that is that the brain relearns how to see again and fills in a lot of missing information. So even though we are providing a crude set of dots that may be outlining an object, the brain is able to fill in a lot of the missing information. So what you see is initially a few spots of lights, but in a month or a few weeks you are actually able to determine large objects and we have shown that amazingly even that one of our patient's that BBC television actually filmed at a home was shooting baskets with his grandson. So it is an amazing thing how much of the brain is able to fill in the missing information, but clearly starts off by seeing spots of light that have been through learning of the brain and that we start seeing large objects and then motion. You can tell which way the objects are moving. You can tell where the door is. You can tell a plate from a cup or a knife. So, this is all what the brain is doing. It is learning this new information.

DR. ROY LEVITT:

And these patients they lost their vision from retinitis pigmentosa.

DR. MARK HUMAYUN:

Yes, all of the patient's to date in the trial whether in the US or internationally had lost their vision because of retinitis pigmentosa, this inherited condition, which damages the rods and cones.

DR. ROY LEVITT:

So they have no visual cells.

DR. MARK HUMAYUN:

That's right. They are end stage, very severe, so they do not have any visual cells, and therefore they cannot see even the brightest light.

For those of you who are just joining in, you are listening to the Revealing Retina on ReachMDXM157, The Channel for Medical Professionals. I am Dr. Roy Levitt and I am speaking with Dr. Mark Humayun and we are discussing artificial vision, artificial retina.

DR. ROY LEVITT:

My question Mark, is has there been any rejection issues?

DR. MARK HUMAYUN:

Yes, the issue of rejection always comes up. Clearly, we are putting in electronics into the body, which is very foreign to the body, but also the body is very corrosive to electronics, so it is a warm saline salty environment and I mean that is the worst thing. Imagine throwing your cell phone in to the ocean, it would not last very long, so in terms of the body's rejection, we have picked materials that are very biocompatible and so we have not seen a rejection of the body, and more importantly we have shown

that these devices could last more than 10 years in the body and the way we did that is in the laboratory you can accelerate by raising the temperature of the testing media, so you put in saline environment, but you elevate it to 87 or even 97 degree centigrade and so you accelerate the failure mode and from that you can calculate by even putting the device in for a year or 2, it is the equivalent of 10 years in the body. So, we have learnt that these devices once implanted can last more than a decade and the tests are still going and they could certainly last longer and that the body does not reject the device.

DR. ROY LEVITT:

What is the longest timeframe that a patient has had this device?

DR. MARK HUMAYUN:

Yes. The first patient that was implanted was in February 2002, so more than 5 years now. So, we have had the first Argus I series implants, all our patients have had it for more than 4 and 5 years. Our Argus II implant, which is the second series implanted. The first Argus I has 16 pixels, the Argus II has 60. The second Argus II implant, which is in the international trial right now has been implanted anywhere from a few months in some patients up to more than a year in others.

DR. ROY LEVITT:

And have you noticed an improvement in the Argus II?

DR. MARK HUMAYUN:

Yeah. Everybody asked the same question you know how much better is Argus II than Argus I and what we are going to do is actually report on some of the results that the American Society of Retina

Specialists meeting in Hawaii later on this year about those results because we are waiting for all the patients to get to a certain limit because since the brain has a lot to add to it, there is a lot of learning. It is unfair to put all subjects in you know even if they have been using it for a month or 2, but the answer of your question we are finding early on and is that yes it is better and what we did was in Argus I, which is very interesting. We compared if we only turned on 4 electrodes versus 16 in that first implant and showed that it made a big difference. So, it seems and it looks the same way that 60 is better than 16 and then some higher number might even be better than 60.

DR. ROY LEVITT:

Now is there any I guess there is no color perceptions, only black and white?

DR. MARK HUMAYUN:

Oh, it is interesting, you are asking about color. Our patients or subjects do report color and they see these deep orange, blue, the sort of yellows, and it is very exciting, but we do not know what in the software or the device is eliciting the color. So one day using the same parameters, we get blue and other days we get orange, so we do need to develop a further understanding about how to do that. Clearly, it is a big aspect of our vision something we all enjoy, but on the other hand in a black and white is very good and largely to do most everything we need to.

DR. ROY LEVITT:

What is the next step?

DR. MARK HUMAYUN:

The next step for this particular device the artificial retina is to get it to a level where we can get

patients or subjects to be able to recognize faces and beyond that can we actually get them to read large print and so we through the Department of Energy Program and also the National Science Foundation Grants, we were pushing the envelope because it is not easy, it is not easy to go from 60 electrodes to lets say a 1000. We have guessed through simulations and sighted volunteers that about 1000, we will get to face recognition and reading vision and so that is where we are sort of aiming at.

DR. ROY LEVITT:

I am going to thank Dr. Mark Humayun for speaking with us about artificial vision.

I am your host, Dr. Roy Levitt and I would like to thank you for listening to Revealing Retina presented by the American Retina Foundation. For more information, visit us online at www.americanretina.org. We welcome your questions and comments about this or any other show. Please send your E-mail to xm@reachmd.com or visit us at www.reachmd.com, our new on demand and new pod cast features will allow you access to our entire program library. Again, thanks for listening.