The miracle of corneal transplants

Researchers at Krembil are striving to be world leaders in ocular regeneration

Shannon Moneo

Patients like Tom Tsokas say that after having corneal transplant surgery, it's "unreal" how much they can now see.

About 10 years ago, Tom Tsokas had to stop driving. He was diagnosed with keratoconus in his right eye during high school, and by his late 40s, it had suddenly gotten worse. "It was like a curtain in front of my eye," says Tom, 56, a Stouffville, Ont., resident who works as an attendant at Toronto General Hospital. "I didn't have pain, but if I was reading a book I had to hold it really close to my face."

Keratoconus is a disease characterized by thinning and protrusion of the cornea, causing an irregular, conical shape and leading to blurred vision. Approximately 50 to 200 out of every 100,000 people develop keratoconus. One possible cause is a decrease in protective antioxidants in the cornea.

Enter Dr. Allan Slomovic, clinician investigator at the Krembil Research Institute and an ophthalmologist specializing in corneal surgery at the Donald K. Johnson Eye Institute. With more than three decades of study and experience, the former clinical psychologist focused on the cornea, the clear window at the front of the eye where surgery results in the highest rates of success, he says. Since completing two prestigious fellowships at Miami's Bascom Palmer Eye Institute, Dr. Slomovic has conducted research into conditions and procedures ranging from penetrating keratoplasty and corneal sensitivity to corneal transplantation and the effects of eye rubbing.

Dr. Slomovic has studied penetrating keratoplasty since 1986, striving to perfect the treatment along the way.

In Tom's case, after a referral by his optometrist in 2011, Dr. Slomovic and his team performed a penetrating keratoplasty. They removed a circular, full-thickness section of Tom's damaged cornea and replaced it with healthy donor tissue that was held in place with stitches.

Following the one-hour, pain-free procedure, Tom wore a patch over his eye for 24 hours. He had the stitches (one-fifth the diameter of a single human hair in size) removed after one year, and gradually the curtain over Tom's eye lifted. "Now I can see, at the bottom of my TV, the scrolling headlines," he says. "It's unreal how much I can see. Before, I couldn't even notice people. Life's gotten better."

Life has also brightened for Harold Keevil, 71. Considered legally blind, he received a new cornea for his left eye, also via penetrating keratoplasty surgery, in February 2017 at Toronto Western Hospital with Dr. Slomovic. The retired stockbroker, who lives in Bracebridge, Ont., had a viral eye infection when he was six. While his right eye did all the heavy lifting, allowing him to be a hockey goalie when younger, Harold had reached the point where he could only see the "E" on the vision chart.

After surgery, like Tom, Harold wore an eye patch, and he has noticed his vision is improving each day. Some of his stitches will be removed after one year, with the remainder taken out months later. Because of his childhood infection, Harold has to take anti-viral drugs for the rest of his life, and he must also take steroids to prevent rejection. But that's all worth it.

"I can now read the eye chart down seven lines," Harold says. "I'm quite delighted. I look forward to getting the vision I had when I was six. And I love photography. This [transplant] should help a lot."

A few centuries ago, the ability to restore someone's vision would have been likened to a miracle. Today, Dr. Slomovic, who is also the Owen and Marta Boris Chair in Stem Cell Vision Research, performs almost 100 corneal transplants each year, bringing light to where there once was darkness.

"I love what I do," says Dr. Slomovic. "But you have to have dedication. There are always improved techniques. You have to stay abreast of the growing technology."

As further proof of how his research has led to pioneering work, in 2010 Dr. Slomovic performed the first successful limbal stem cell transplant for the new ocular stem cell program at University Health Network (UHN). He used cells from Tori Binns's left eye, which were removed and attached to her brother Taylor's left eye. Taylor, 23 at the time, had stem cell deficiency, a rare condition where stem cells that had kept his cornea clear and healthy had been damaged and then destroyed due to wearing contact lenses. Following surgery, Taylor could see well enough to drive, and his eye pain substantially diminished. Dr. Slomovic has since completed several limbal stem cell transplants and is working to make UHN the hands-down leader in ocular regeneration.

One thing that has remained constant is the cornea itself, likened to a three-layer cookie. "It's the only tissue in your body that is perfectly clear, that has no blood vessels," says Dr. Slomovic.

Dr. David Rootman recalls that when he began performing corneal surgery in 1988, there was only one corneal transplant method. "We cut all three layers and replaced them [with a donor's eye tissue]. It worked relatively well, but there was a long healing time." The outermost layer of the cornea is the epithelium, the middle layer is the stroma and the bottom layer is the endothelium.

Also a Krembil scientist, clinician investigator and an ophthalmologist specializing in corneal surgery at the Donald K. Johnson Eye Institute, Dr. Rootman says it could take many months before the transplant stabilized. During that time, and up to many years later, a 10 to 30 per cent rejection rate was possible. "And after the stitches are removed, the only thing holding it in place is scar tissue, which is not terribly strong," he says. People who fell and hit their eye could undo the transplant.

But in 2002, Dr. Rootman became the first Canadian surgeon to perform the Posterior Lamellar Keratoplasty (PLK) procedure, which eventually evolved into the Descemet's Membrane Endothelial Keratoplasty (DMEK) procedure, a revolutionary technique in which only the diseased layers in the cornea are replaced, leaving healthy areas intact.

"I only take the inner 2 per cent – 10 to 15 microns versus 100 microns. Ten microns are the equivalent of two red blood cells stacked on top of one another," Dr. Rootman says.

Like Dr. Slomovic, Dr. Rootman has been honing procedures that were once cutting edge. "There's always progress. We've studied our results and continue to improve our techniques," he says.

First he makes a very small incision where the cornea and the white part of the eye (sclera) meet. Looking through a 100-pound microscope that provides 20 to 40 times magnification, Dr. Rootman peels off the endothelium and Descemet's membrane from the donor tissue, a very exacting procedure. The same thing is done to the patient's cornea. "It's like peeling a very thin postage stamp," Dr. Rootman says. He then injects what he calls the "scroll" of the endothelium through a tiny glass tube, and he unfurls it inside the eye.

DMEK has proven very successful. The single, small incision either self-seals or requires only one or two sutures, making the procedure safer. As well, the rejection rate is a mere 1 per cent, compared to donor rejection rates that can reach 30 per cent. DMEK is a great choice for those patients who have rejected previous transplants. "Within one or two months, patients recover and can see remarkably [well]. It's really solved a lot of issues around corneal transplantations," Dr. Rootman says.

Having performed more than 400 DMEKs, Dr. Rootman now travels the world. He was recently in Israel, teaching other surgeons how to perform the meticulous surgery targeted at the back of the cornea. "I love to work with my hands and spread these techniques, and microsurgery gives me the chance," he

Dr. David Rootman, left, and Dr. Allan Slomovic, right, are relentless in their pursuit of new techniques and technologies.

"I love what I do. But you have to have dedication. There are always improved techniques."

– Dr. Allan Slomovic

says. "I get a kick out of showing people how to do surgery."

When the front of the cornea is scarred or diseased, a different procedure called deep anterior lamellar keratoplasty may be used. "It's definitely harder. You have to separate the internal membrane without having it rip," says Dr. Rootman, who has performed hundreds of these transplants. "You remove the top and middle layers and preserve the inner layer." Healthy donor tissue replaces what was removed. Because the inner layer (endothelium) is left intact, the integrity of the cornea is maintained, healing is relatively fast, rejection is unlikely and the transplant may last a lifetime.

One area Dr. Rootman would like to further target relates to work being done in Japan, where cells from living or deceased donors are taken. The cornea cells are then mixed with an enzyme that makes them float on the surface of a petri dish, where the cells grow over a number of days. They are then injected into a patient's eye. "I would like to start trials," he says.

Dr. Slomovic, meanwhile, has been enhancing his artificial corneal transplant skills at Toronto Western Hospital over the last decade. He does about 15 each year, compared to the 75 non-artificial transplants he performs. "It's sort of like a last-ditch effort. When they come to this point, there's nothing else," he says. For patients who have rejected donor tissues or had three or more transplants, the acrylic and titanium cornea becomes the ultimate solution.

While both researchers are approaching retirement, they are not ready to hang up their lab coats just yet. Plus, there's much work yet to be done. "I'm having too much fun to stop now," says Dr. Slomovic, 65.

Dr. Rootman, 61, says: "I feel like I'm the luckiest person in the world. I'm doing what I love and helping people. The work is beautiful." ■