GENERAL SURGERY NEWS

In the News

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# Surgeon Repairs Spinal Cord With Omentum, Helps Paralyzed Woman Walk

By Victoria Stern

In 1994, general surgeon Harry Goldsmith, MD, received an unexpected telephone call from Germany. The young woman on the line, a 24-year-old named Andrea, told Dr. Goldsmith that she was paralyzed from the waist down.

Andrea had fractured her spine in a high-speed skiing accident a year earlier. When she learned about a novel technique that Dr. Goldsmith had developed to repair injured spinal cords, she reached out to him, hoping he could help her.

Dr. Goldsmith explained to Andrea that the spinal cord technique was still experimental. In fact, he had never performed it on a human patient. "I stressed to her that the procedure was risky, and I didn't yet know what could happen in a human patient," he said. "And if it failed, it might cost her her life."

Despite the risks, Andrea insisted on the surgery. A few weeks later, Dr. Goldsmith flew to Munich to meet her.

For the past 30 years, Dr. Goldsmith, who is clinical professor of neurological surgery, University of California, Davis, has been developing a technique to repair spinal cord injuries. He has largely focused on the therapeutic potential of the omentum, a thin sheet of fat, blood vessels and connective tissue that drapes across the abdomen and intestines. Studies have shown that the omentum has many restorative properties. For instance, the omentum can repair vascular damage and provide blood to the heart, spinal cord and brain (*Acta Neurochir* 1990;106:145-152).

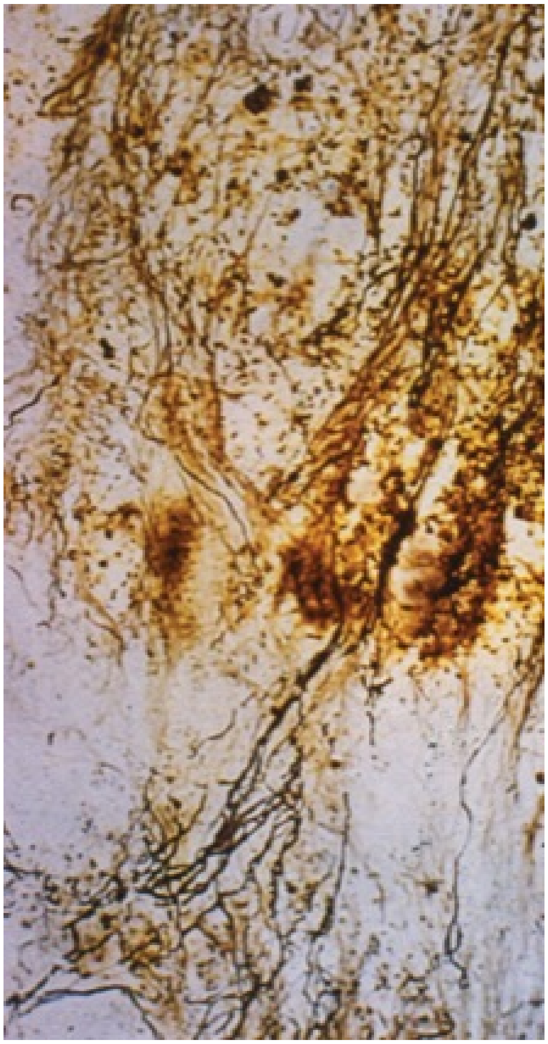

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**Figure 1. Axons exiting distal end of omental-collagen bridge. Collagen is in the process of biodegrading.**

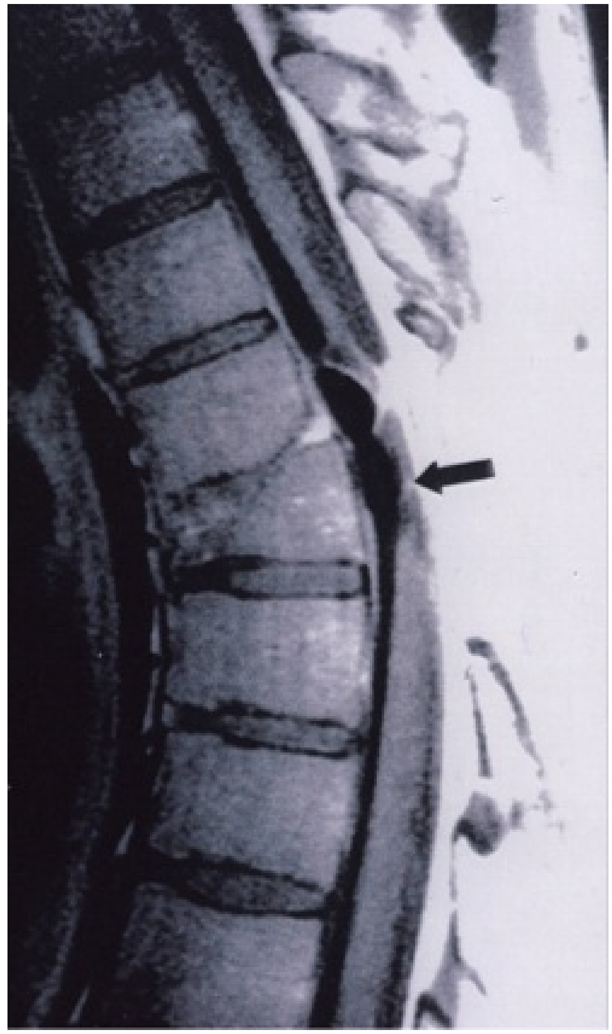

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**Figure 2. Arrow points to radiologically reported total anatomic spinal cord transection.**

(For more on Dr. Goldsmith's work on the omentum in Alzheimer's disease, see *General Surgery News* 2014;41[3]:1; www.generalsurgerynews.com/In-the-News/Article/03-14/Omentum-Surgery-Explored-For-Alzheimer's-Disease/26118.)

Dr. Goldsmith wondered whether the omentum could help heal an injured spinal cord. To test this idea, he conducted experiments in the 1980s to determine whether he could restore motor function in adult cats with severe spinal cord injuries by placing the omentum on the damaged cord (*Paraplegia* 1985;23:100-112). Dr. Goldsmith found that, when he placed the omentum on the spinal cord within hours of the injury, no scar formed at 30 days. However, when he placed the omentum even six hours after injury, the cats developed severe scarring at 30 days. Of note, the cats with no scarring regained mobility in their limbs and were able to walk again.

"I showed that, using the omentum, it is possible to prevent the scar tissue that develops very soon after a spinal cord injury, a finding that could be hugely important for people's recovery," he said.

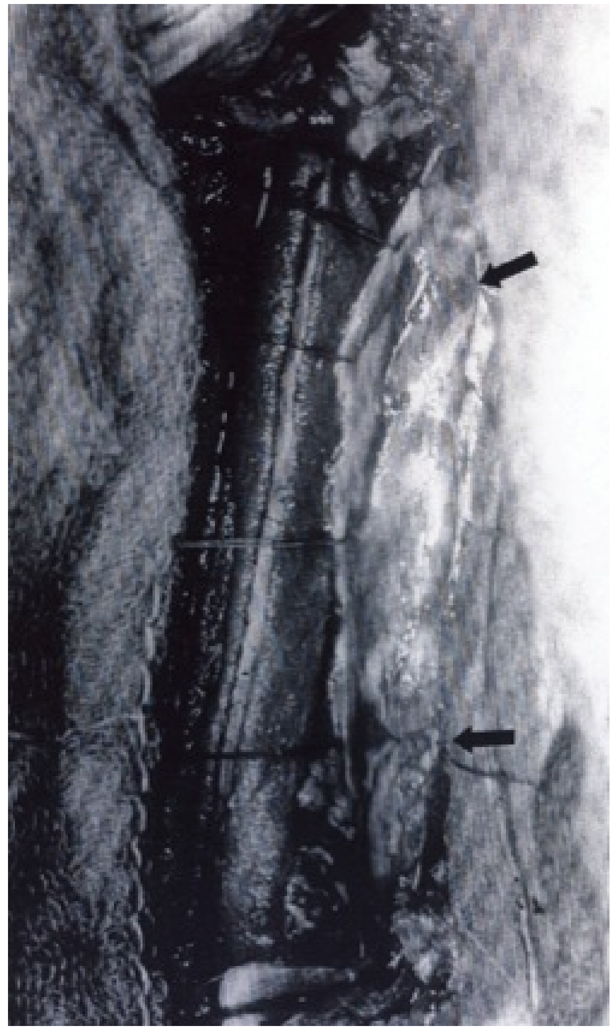

**Figure 3. Arrows point to spinal cord scar between T6-T8.**

Dr. Goldsmith hypothesized that the omentum may prevent scar formation by absorbing fibrinogen, a protein that plays a central role in blood coagulation and tissue repair. More recent studies have shown that the omentum can indeed absorb fibrinogen and that an overabundance of the protein may cause scar tissue to form within hours of a traumatic injury (*Blood* 2001;97:3691-3698; *J Neurosci* 2010;30:5843-5854). This scar tissue essentially creates a barrier through which axons cannot penetrate, encasing the injured spinal cord and cutting off communication between the spine and brain. If preventing scar tissue from forming can promote recovery, Dr. Goldsmith thought that perhaps removing the scar tissue that develops after a spinal cord injury also could help repair the damage.

In a follow-up animal study, Dr. Goldsmith excised a piece of the cat's spinal cord, reconstructed the cord by patching the gap with collagen and then draped the omentum over the injured region. He subsequently observed axons move through the collagen bridge down into the distal spinal cord at a rate of 1 mm per day. Removing the scar tissue allowed new axons to grow.

Although the preliminary results showed that removing scar tissue and placing the omentum on the injury could potentially restore axon growth and motor function in animals, the studies provided no guarantee that humans would respond favorably. So far, techniques that have yielded promising results in animals with spinal cord injuries have not translated to humans. Thus, performing this procedure on the first human patient presented many uncertainties and potential risks.

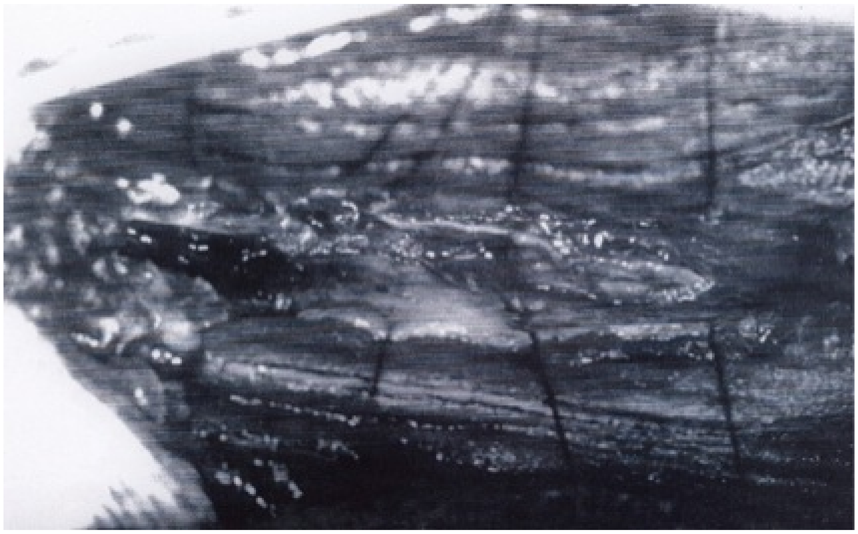

**Figure 4. Surgical absence of spinal cord between T6-T8.**

When Dr. Goldsmith touched down in Munich, he met Andrea and her husband in their hotel room. After reviewing her MRI scans, Dr. Goldsmith saw that Andrea had experienced a complete anatomic transection at her T6-T7 vertebrae (*Neurol Res* 2005;27:115-123).

Although Dr. Goldsmith and Andrea decided to go forward with the surgery, it took many months before Dr. Goldsmith could secure a facility willing to host the experimental procedure, a neurosurgeon prepared to lend his expertise in the operating room and a physician inclined to supply Dr. Goldsmith with the collagen necessary to perform the repair. Finally, in 1996, almost 3.5 years after Andrea suffered her injury, Dr. Goldsmith had everything in place for the procedure.

During the surgery, Dr. Goldsmith observed extensive scarring around the spinal cord. "I thought we'd see a small scar, but when we exposed the spinal cord, we saw 1.6 inches of scar tissue," Dr. Goldsmith said. "I worried what the recovery would be like if we took out that much scar tissue on the spinal cord."

But Dr. Goldsmith removed 1.6 inches of the scarred spinal cord, reconstructing it by filling the cavity with 5 $cm^3$ of a semiliquid collagen that hardened at room temperature. Dr. Goldsmith then partially detached the omentum from the abdomen, keeping its main blood supply intact, and placed the vascularized omental pedicle on the collagen bridge.

Eight months after the surgery, Dr. Goldsmith received a call from Germany. It was Andrea. She explained that she could now move her ankles and legs under water. Skeptical at first, Dr. Goldsmith could not deny her progress after she sent him video proof.

Excited by the extensive improvement, especially in light of the level of damage, Dr. Goldsmith arranged for Andrea to receive full-time physical therapy at a facility in Phoenix.

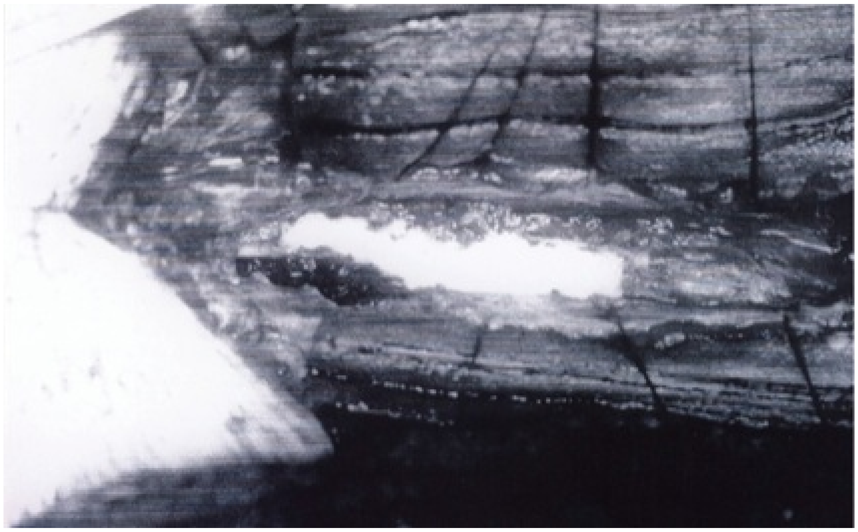

**Figure 5. Collagen filling extensive spinal cord defect between T6-T8.**

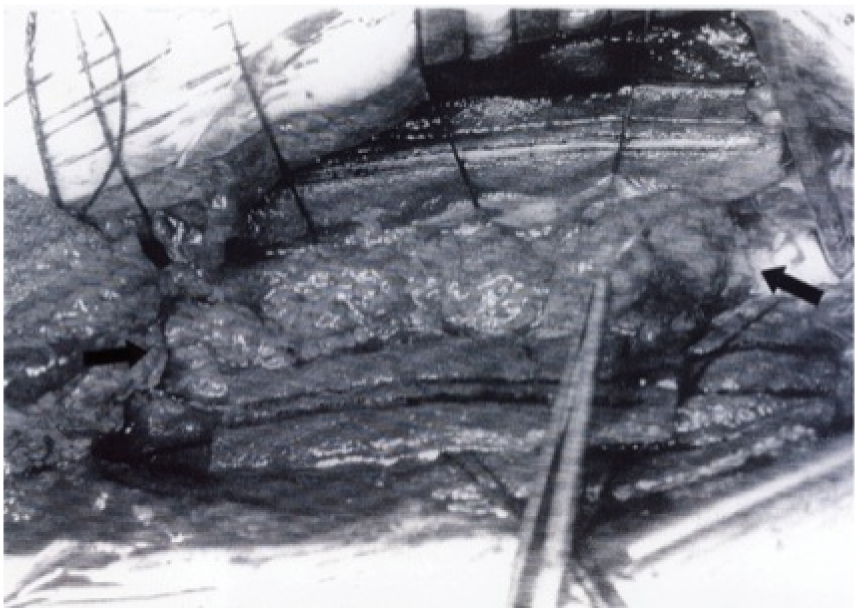

**Figure 6. Arrows show intact omental pedicle placed over collagen bridge.**

"A friend of mine, Arnie Fonseca Jr., ran a physiotherapy unit in Phoenix, and when I told him about Andrea, he said he would take care of her at no cost," Dr. Goldsmith said.

After 1.5 years of extensive physical therapy in Phoenix, Andrea could walk with the aid of a walker. A series of MRIs taken after the surgery and each subsequent year demonstrated significant spinal cord recovery.

"I have shown through multiple MRIs that the spinal cord can heal after this procedure and after intense physical therapy," Dr. Goldsmith said.

Dr. Goldsmith wanted to share this success. He wrote several papers and presented at conferences over the years, but his technique garnered little interest from the medical community; that is, until he met married researchers Giorgio Brunelli, MD, PhD, emeritus professor of orthopedics and director of the Foundation for Research on Spinal Cord Lesions, and Luisa Monini, MD, a researcher on spinal cord lesions and repair. Drs. Brunelli and Monini first heard about Dr. Goldsmith's operation at a meeting in Europe several years earlier and invited him to present his research in December 2015 at the International Symposium on Experimental and Clinical Spinal Cord Repair and Regeneration, in Brescia, Italy.

"We were all amazed when we saw this woman, who had a full lesion to the spinal cord at level T6-T7, walking," Dr. Monini said. "The video showed that two years of rehabilitation following the operation allowed her to walk again. So if it's not a miracle, it surely represents a great success for surgery and for an outstanding neurosurgeon."

At the symposium, Dr. Goldsmith's presentation caught the eye of Hari Shanker Sharma, PhD, professor of neurobiology in the Department of Surgical Sciences, University Hospital, Uppsala University, Sweden. "As far as I've seen, the results of Dr. Goldsmith's procedure are outstanding," said Dr. Sharma, editor of the *American Journal of Neuroprotection and Neuroregeneration*. Dr. Sharma invited Dr. Goldsmith to submit a paper to the journal, detailing this case study. The paper was recently accepted for publication.

Dr. Monini believes that removing the scar tissue from the spinal cord is fundamental to the procedure's success, as is placing the omentum on the spinal cord to supply blood to the region and prevent further scarring. Despite its potential, this technique still requires extensive study before experts can demonstrate its safety and effectiveness in a wider patient population. Pursuing such research is particularly important given that there are currently no approved strategies to reverse spinal cord trauma, and treatment options are limited. To accelerate progress, Dr. Monini stressed the importance of fostering a collaborative effort among spinal cord experts and surgeons who could pool their resources to examine innovative treatments.

Dr. Sharma agreed, noting, "We have not seen dramatic results in patients with spinal cord injuries, which means every innovation that shows some promise in patients is worth exploring further. Dr. Goldsmith's technique represents such a strategy that could help the many people who suffer from spinal cord injuries."

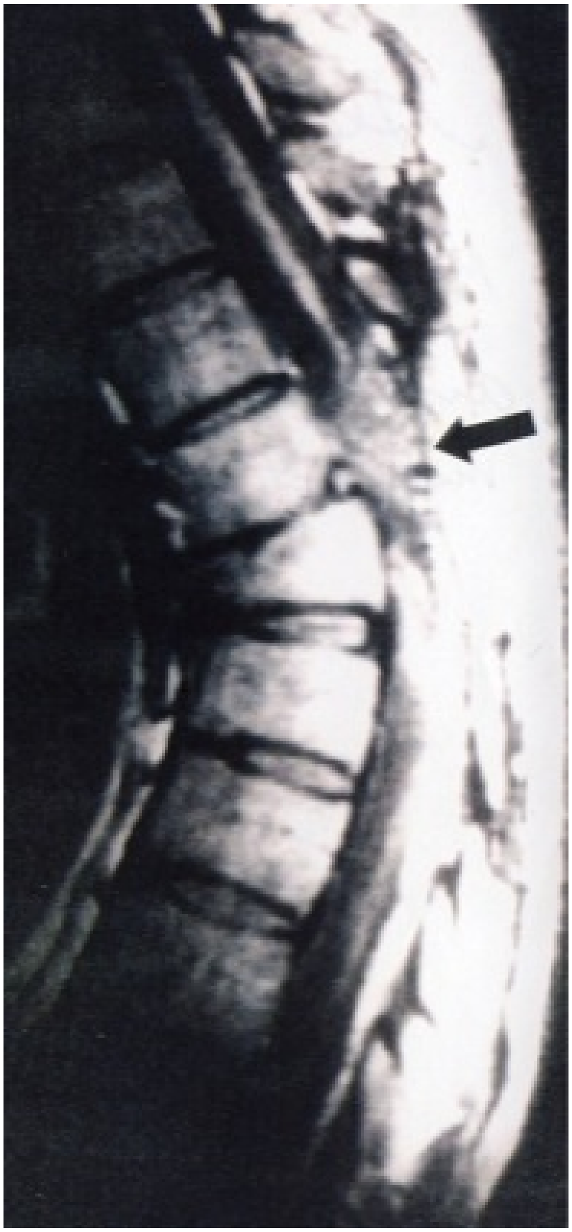

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**Figure 7. MRI of spinal cord one year after spinal cord reconstruction. Arrow points to soft tissue mass at T6-T8.**

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**Figure 8. MRI six years after surgery showing connection between proximal and distal segments of previously divided spinal cord.**