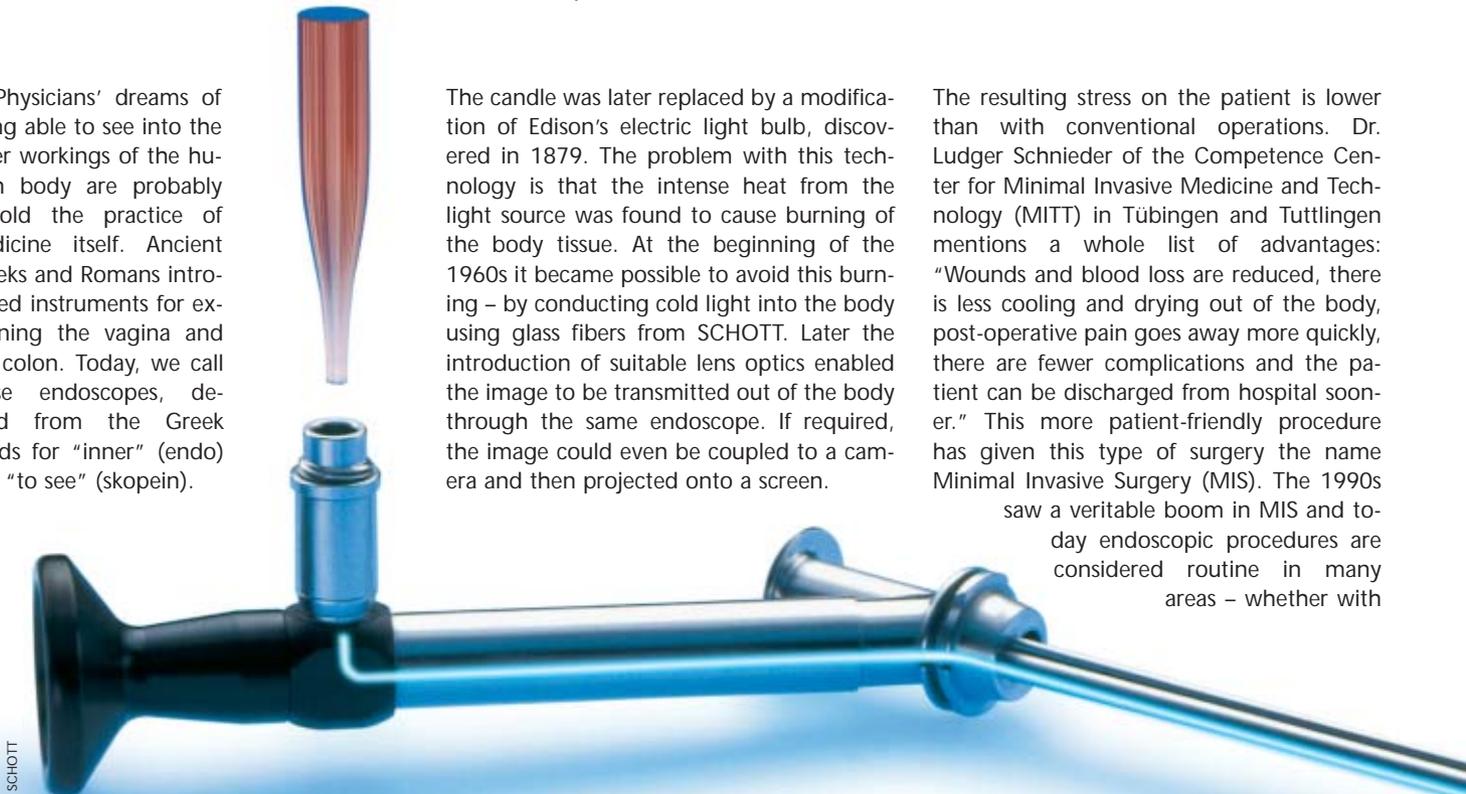


Working through the Keyhole

Many surgical operations are becoming increasingly less invasive and post-operative scarring is being reduced to a minimum. Endoscopes are an indispensable tool for many surgical procedures. These instruments enable surgeons to see the "invisible."

► Physicians' dreams of being able to see into the inner workings of the human body are probably as old as the practice of medicine itself. Ancient Greeks and Romans introduced instruments for examining the vagina and the colon. Today, we call these endoscopes, derived from the Greek words for "inner" (endo) and "to see" (skopein).

Fiber optic components from SCHOTT are important elements in medical endoscopes.



The candle was later replaced by a modification of Edison's electric light bulb, discovered in 1879. The problem with this technology is that the intense heat from the light source was found to cause burning of the body tissue. At the beginning of the 1960s it became possible to avoid this burning – by conducting cold light into the body using glass fibers from SCHOTT. Later the introduction of suitable lens optics enabled the image to be transmitted out of the body through the same endoscope. If required, the image could even be coupled to a camera and then projected onto a screen.

The resulting stress on the patient is lower than with conventional operations. Dr. Ludger Schnieder of the Competence Center for Minimal Invasive Medicine and Technology (MITT) in Tübingen and Tuttlingen mentions a whole list of advantages: "Wounds and blood loss are reduced, there is less cooling and drying out of the body, post-operative pain goes away more quickly, there are fewer complications and the patient can be discharged from hospital sooner." This more patient-friendly procedure has given this type of surgery the name Minimal Invasive Surgery (MIS). The 1990s saw a veritable boom in MIS and today endoscopic procedures are considered routine in many areas – whether with

The first reference to a built-in light source in endoscopy was in 1587. The Italian Gulio Cesare Aranzi made use of a camera obscura technique to collect daylight for examining a nasal cavity. The first photographs date back to 1807, when the German physician Dr. Philip Bozzini of Frankfurt developed "a simple apparatus for illuminating the inner cavities and spaces of the living animal body," as he described it in his monograph. His method was to direct the light from a candle down an aluminum tube into the body and bring out the reflected light. Although the technology has progressed since then, this is still the basic principle of endoscopy today. Dr. Bozzini was the first to envision the application of endoscopes in urology, gynecology and ear, nose and throat surgery.

Minimal invasive surgery

Endoscopic operations on the intestines were first carried out in 1980, followed by appendectomies in 1983 and gall bladder removals in 1988. The advantages of these techniques were obvious: there was no need to fully open the stomach cavity. Just a few small incisions are required in endoscopic surgery.

One incision is for the endoscope so that the physician can illuminate and view the surgical procedure, as if through a keyhole. The other incisions are used for surgical instruments. The endoscope and the surgical instruments are passed through fine tubes called trocars that keep the incisions open for surgery.

the meniscus, the groin, stomach, esophagus, pancreas, gall bladder, liver, adrenal gland or the brain. In industrialized countries about 70 percent of all gall bladders are now removed in this manner. In the United States the figure is more than 85 percent. Today, MIS makes it possible to carry out delicate eye surgery procedures that were formerly virtually impossible. The number of minimal invasive operations on the retina now numbers some 15,000 per year in Germany alone. There are even procedures for unblocking tear ducts with an endoscope that have been developed in Switzerland.

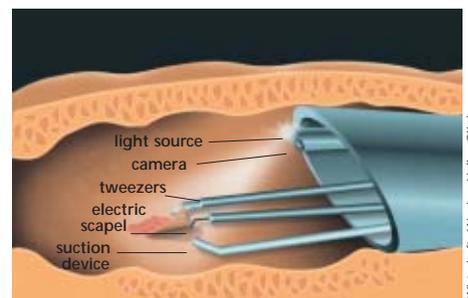
The potential is high, and it is only a lack of training that prevents even greater use of MIS, according to Professor Reinhard Bittner



Helios Clinic Müllheim

Minimal invasive surgery is routine procedure at the Helios Clinic at Müllheim in Baden-Württemberg.

A look inside the tube: an endoscope with various devices and a light for minimal invasive surgery.



Wirtschafts Woche, Helios Clinic

of the German minimal invasive surgery study group known as CAMIC. Producers of endoscopes are already selling well over 50,000 instruments a year and can expect orders to increase.

High Quality Standards

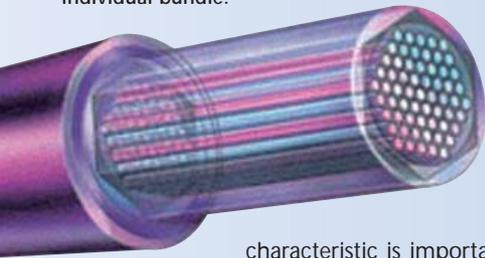
SCHOTT supplies the highest quality light guides to all the major producers of endoscopes. Ideally, endoscopes should be resistant to temperature and pressure so that they can be sterilized in an autoclave after

each use, gently and without chemicals. It is usual to apply steam at a temperature of 132° Celsius at a pressure of two bar. "That is not a problem with our glass fibers," says Jürgen Freitag of SCHOTT Fiberoptics in Mainz.

The specially designed SCHOTT fibers provide high transmission with a minimal loss of light. Coupling elements, or glass fiber

cones feed the light into the endoscope like a funnel. They are constructed in such a way that when the light cone leaves the endoscope, an exit illumination angle of up to 120° Celsius can be attained. This particular

In endoscopes many thousands of glass fibers are arranged in precise alignment in each individual bundle.



SCHOTT

characteristic is important in providing illumination to an area in the body as large as possible, without moving the endoscope.

The composition of the glass is critical in determining the illumination beam angle. The core of the fiber must be made of a glass with a high refractive index. "This property is obtained by adding doping materials," says Freitag. In order to avoid impurities entering the glass during doping, which would later result in tinting, SCHOTT supplies ultrapure doping materials to ensure good color fidelity. Color tinting can be a

problem for surgeons. As an example, a red tint would prevent them from differentiating between diseased tissue and normal tissue containing blood.

Giving the group of flexible endoscopes the same characteristics that rigid models already have today is one objective that endoscope producers have not yet achieved. Flexible types have the advantage of enabling one to look around any corner. Currently, they are used mainly in diagnostics, for instance in gastroscopy, but only rarely in surgical procedures. The complicated optics require up to 100,000 image points to be aligned in an absolutely precise sequence in order to transmit out of the body. They are expensive and cannot be sterilized in an autoclave but have to be cleaned with chemicals, which can be a big disadvantage for clinics.

In many fields of surgery, however, physicians are still quite happy with the rigid en-

doscopes. Ludger Schnieder of the MITT would rather see improvements in other instruments. "We are now at a stage where the size of surgical instruments must be reduced, for instance in eye, neural and pediatric surgery."

Extensive technical expertise

SCHOTT supplies endoscope manufacturers with a wide range of components. They include high resolution imaging bundles, coated light guides with finished ends and optical coupling elements that feed the light from the light guide into the endoscope. Manufacturing locations are in Mainz and at two U.S. sites – one in Southbridge, Massachusetts, and the other in Auburn, New York. SCHOTT Fiber Optics in the United States concentrates mainly on developing and producing coherent image transmitting glass fiber bundles needed for flexible endoscopes. Here, the key is the precise arrangement of the many thousands of glass fibers in each bundle. These fibers can be up to two meters long and are typically no more than six to eight micrometers in diameter – just one-tenth the diameter of a human hair.

Endoscopes are not only in demand for medical uses but are also found in industrial applications. For example, aircraft inspectors use them to seek out hairline cracks in turbine vanes, and customs officers employ flexible endoscopes to peer into the gas tanks of vehicles. ◀

Some 120,000 kilometers of glass fiber made of special optical glass leave SCHOTT production facilities every day.



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Surgery in utero

Sometimes television can change lives. When Thomas Kohl was studying medicine in Essen, he happened to see a TV report one evening about Michael Harrison, the first surgeon in the world to perform surgery on a fetus while still in the womb. From that moment on, Kohl knew what he wanted to do. Several years later he spent three research years at the University of California at San Francisco, where Harrison also worked. He began to develop minimal invasive surgery techniques using sheep fetuses. Today, the now 40-year-old pediatrician and prenatal physician is setting up a working group for Human Fetal Surgery at the University Clinic in Bonn. In 2002 the first en-

doscopic surgery was performed on a fetus with a cleft spine, (Spina bifida). Through a trocar as thin as a straw, Kohl covered the exposed spinal cord with a tiny Teflon patch. It was extremely delicate work – the diameter of the trocar was just one third the usual size in endoscopic procedures.

Operations on the unborn with a life-threatening congenital diaphragmatic hernia are another planned area of application for fetal surgery. With this birth defect, the organs in the abdomen protrude into the chest cavity, thus impairing normal lung growth. In addition, Kohl is developing prenatal heart surgery at the University of Muenster. In trial

tests his team was already successful in correcting heart defects in fetal sheep.

If such surgery becomes routine procedure, Dr. Kohl and his staff will have a lot of work on their hands. About one baby in 3,000 is born with a cleft spine today, and the statistics for congenital diaphragmatic hernia are similar. Eight in 1,000 newborn babies have a heart defect. Thomas Kohl's thesis required for his qualification as a university lecturer, entitled on the "Development of Fetoscopic Surgical Methods," was awarded the Werner Forssmann Prize, which is presented every year by the Board of Cardiology 2000 of the University of Bochum.