Imaging the anterior segment with optical coherence tomography (OCT) has become a requisite element of corneal and refractive surgery and anterior segment surgery in general. Because of the utility of these diagnostic devices, many refractive and corneal surgeons have OCT instruments positioned in or near the operating room to check or recheck a measurement between surgeries. Although this feedback is extremely valuable, obtaining OCT images during surgery requires surgeons to take extra steps that slow down the surgical process.

An integrated set-up, in which OCT is integrated into surgical microscopes, lasers, and phaco machines, would eliminate these extra steps and allow surgeons to image cross-sections of most ocular structures intraoperatively. Currently no such instrumentation exists; however, OCT has been integrated into slit-lamp technologies (see High-Quality Images of the Anterior and Posterior Segments Obtained With an Integrated OCT System.) This article explores some of the potential benefits of integrated surgical OCT technology.

**PRECISION AND DEFINITION**

Depending on the wavelength and technology of particular OCT devices, we are currently able to obtain differing quality and precision of images. Generally speaking, the smaller the area to be explored, the higher the definition we can obtain with current OCT instruments. The larger the area to be explored, the less definition. For example, when we are exploring a small part of the cornea or the retina, modern spectral-domain OCT instruments can provide extremely precise and high-definition views of this small section of the eye. If we want to have an image of the whole eye or the whole cornea, sclera, or anterior chamber, OCT is still useful, but the definition of these maps is lower.

Depending on the type of surgery being performed and the reason for using OCT, the ideal scenario would be to have the capacity to view large areas at high definition, providing surgeons with more information to make surgical decisions. Precision may not be as important during certain parts of cataract surgery as it is in retinal or corneal surgery. For example, it may not be necessary to pinpoint the location of a phakic or pseudophakic IOL with a device that provides extremely high precision. In contrast, creating a capsulorrhexis or an endothelial lamellar keratoplasty requires high precision, focusing on the thin layer atop the crystalline lens or on the back of the cornea. Therefore, OCT might be not only useful but mandatory for some surgical steps. For other surgical steps, high definition might not be as important as the size of the viewing area.

**TRADEOFF FOR CORNEAL SURGERY**

This tradeoff between precision and the viewing area is evident in OCT examinations of the cornea. Currently we cannot obtain a cross-section of the complete cornea in high definition. If we want to evaluate a small diseased area, for instance a corneal scar or corneal ulcer, OCT can provide a high-definition image, but for a limbus-to-limbus view the resolution will be lower.

For lamellar corneal surgery, such as posterior or anterior lamellar keratoplasty, it is important to see the complete cornea. With the technology available today, we lose definition and precision in favor of obtaining wide corneal views for these procedures. Additionally, because OCT is not currently integrated with surgical microscopes, evaluating cuts made during lamellar surgery requires surgeons to make the cut in the operating room and then move the patient to another room for the OCT scan. Once the map is evaluated, the patient is moved back into the operating room and surgery is completed. Integrating the two technologies—OCT

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**TAKE-HOME MESSAGE**

- An integrated set-up would eliminate extra surgical steps and allow surgeons to image cross-sections of most ocular structures intraoperatively.
- The ideal technology would allow surgeons to view large areas at high definition.
- Surgically integrated OCT could increase the precision of surgical maneuvers.
High-Quality Images of the Anterior and Posterior Segments Obtained With an Integrated OCT System

BY M. STEHOUWER, MD; AND FRANK VERBRAAK, MD, PhD

The SL SCAN-1 (Topcon Europe Medical BV, Capelle a/d IJssel, Netherlands), a Fourier-domain optical coherence tomography (FD-OCT) imaging system integrated into a slit lamp, provides high-quality images of both anterior and posterior segments, as demonstrated in our two studies in *Eye* 2 (Figure 1). To evaluate this device, we observed representative pathologies of the posterior and anterior segments with the slit lamp and simultaneously scanned with the SL SCAN-1. The OCT system did not interfere with the normal functionality of the slit lamp.

We compared the quality of images of the posterior segment made with the device with images made by a standalone FD-OCT system (3D-OCT-1000 Mark II, Topcon). Posterior pole images made with the slit-lamp–integrated FD-OCT were of sufficient quality to allow correct interpretation of the observed pathologic conditions. Conclusions based on the images of the posterior segment taken with the SL SCAN-1 were identical to the conclusions based on the images made with the standalone FD-OCT system.

Additionally, images could be made of the anterior segment, providing high-quality images of the cornea and the iris. The images provided detailed information of corneal pathology (lattice dystrophy; Figure 2) and visualized the position of a Baerveldt tube (Abbott Medical Optics Inc., Santa Ana, California) in the anterior chamber (Figure 3). Using a three-mirror contact lens, the anterior chamber angle could be scanned through the gonio mirror (Figure 4). The other mirrors of the three-mirror contact lens could be used to obtain scans of the peripheral retina.

With the SL SCAN-1, OCT scans can be obtained during slit-lamp examinations. High-quality OCT images can be made of lesions observed with the slit lamp in the anterior and posterior segments, including lesions visible only through a three-mirror contact lens. We found that this device increased the efficiency of examination and accuracy of diagnosis. We also found that combining slit-lamp examinations and OCT scans improved patient comfort, reducing the examination time by needing to use only one device.

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and surgical microscope—would eliminate these steps.

Current OCT technology can take as a reference only an anterior surface and not a posterior surface (see *Fourier-Domain OCT for the Anterior Segment*). This is a technical limitation, especially in terms of the cornea and crystalline lens. For example, in lamellar surgery if we want to create a cut parallel to the posterior surface, current OCT is unable to provide a posterior reference. Once surgeons are able to reference the posterior surface, many companies will consider integrating OCT into their femtosecond and excimer lasers.
CONCLUSION

With the exception of investigational femtosecond lasers for cataract surgery now in development, at this time there are no surgical instruments clinically available in which OCT is integrated. Many refractive surgeons—myself included—are hopeful that OCT will be integrated into these and other surgical instruments in the near future. In my opinion, industry has not made integrated OCT instruments available because of economic limitations, not technical ones. If there is only one OCT in a practice, for example, it is more logical to have the device as an independent unit to evaluate clinical patients than to have it tied to surgical instruments. Therefore, an integrated OCT-microscope set-up would be not be cost-effective in some cases.

The true advantage of surgically integrated OCT, when it becomes available, will be to increase the precision of surgical maneuvers. Improvements in OCT technology will allow us to operate better, and integrating this capacity into surgical instruments will allow us to operate more efficiently and, more important, with a higher safety profile.

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