Use of the Visante for Anterior Segment Ocular Coherence Tomography

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ABSTRACT

The Visante OCT from Zeiss (Carl Zeiss, Germany) provides excellent high-resolution images of the anterior segment of the eye. It uses low-coherence interferometry to produce cross-sectional tomographs of the cornea and anterior chamber. It is a noncontact instrument that captures its images quickly and with little technician effort.

Once an image has been captured, it can be analyzed with 1 or multiple tools. There are many applications for the Visante OCT including accurate topography for keratoconus, narrow-angle assessment, planning and after both LASIK and corneal surgery, patient education, and research.

One limitation of the Visante OCT at the time of this writing is in its software development. There are relatively few tools, and they are limited in their use and application. The other limitation is the inability of its 1310-nm wavelength to penetrate pigmented tissue. Therefore, the Visante OCT cannot image anything past the pigmented epithelium of the iris. Overall, the Visante OCT provides excellent images of the cornea and anterior chamber.

HISTORICAL PERSPECTIVE

Imaging the ocular adnexae has evolved significantly since its conception. The early forms of capturing images began with the use of film-based slit-lamp cameras. Ultrasound A and B scans gave axial length, position/thickness of the lens, anterior chamber depth, and information about the posterior pole when media opacities made it impossible to view. Although these forms of imaging still hold value, computer technology has allowed for advancements in the imaging field. The corneal shape can be mapped with either axial, tangential, or elevation-based topographers. A 200-degree image of the fundus can be captured through an undilated pupil with the Optomap. Cross-sectional images of the macula and 3-dimensional reconstructions of the optic nerve are provided with the Heidelberg Retina Tomograph II, scanning laser tomography or Optical Coherence Tomography (OCT). Until recently, there had been no reliable or useful method of imaging the anterior segment in cross-section. Now UBM (ultrasound biomicroscope) or OCTs provide detailed cross-sectional images of the cornea, anterior chamber, angle, iris, and in the case of ultrasound, the lens. The Visante OCT is one such device, using OCT to image the anterior segment.

WHAT IS THE VISANTE OCT?

The Zeiss Visante OCT Model 1000\(^1\) can provide “detailed in vivo examination of the anterior segment of the eye, without eye contact.” It provides high-resolution cross-sectional images that can later be evaluated and analyzed using measuring tools. The instrument uses low-coherence interferometry to pass a light into the eye along both a sample and a reference path. Both return signals are combined at a photodetector. The combined signal is reconstructed to form a digital volumetric model of the cornea. In other words, the Visante software constructs an optical tomogram.
INSTRUCTIONS FOR USE

The Visante OCT (Fig. 1) has been designed for easy use with little operator training. Capturing high-quality images takes little time, and multiple images can be obtained in rapid succession. Simplified instructions for the use of the Visante OCT are as follows:

1. Enter patient data

2. Align patient. The Visante’s orientation of chin and head rests is such that the patient gazes at a depressed angle to give more patient comfort.

3. Ask the patient to look at the “asterisk” or “flower” fixation target

4. Instead of using the x, y, z controls, it is easier to align the eye through the video feedback window positioned in the bottom left of the display terminal. In the center of the pupil, there will be a tiny white dot representing the “red reflex.” By clicking on this dot, the x and y axes will automatically center on this position. By scrolling the center wheel of the mouse, the head/chin rest will move in and out from the machine altering the z axis.

5. Adjusting options such as polarization, angle of fixation, noise, saturation, and video feedback window can be done from tabs in the lower right of the display terminal

Polarization adjustment is key for good images of LASIK flaps.

6. Final adjustments to center the eye can be done with either x and y buttons or by again clicking on a white dot in the image of the pupil in the video feedback window

It is easier and quicker to click on the white dot.

7. The eye is centered when the solid white reflex coming through the center of the cross-sectional image is aligned with the yellow vertical indicator and the anterior surface of the cornea is between the 2 horizontal green lines.

8. Finally, the quickest method of capturing an image is to click the right mouse button

The image is dynamic and constantly being refreshed. As the operator, it will at times be frustrating that constant adjustment is required. Practice makes perfect.

When setting up user privileges, it makes most sense to give all operators Reading Physician Privileges. Reading Physician Privileges allow the user to manipulate all the tools. At our office, it did not make sense for only 1 operator to be able to use the tools when analyzing images.

IMAGING MODES

The Visante OCT has 6 imaging modes:

1. High-Resolution Cornea Single
2. High-Resolution Cornea Quad

FIGURE 1. Visante OCT.
3. Pachymetry
4. Anterior Segment Single
5. Anterior Segment Double
6. Anterior Segment Quad

In the Quad mode of both High-Resolution Cornea and Anterior Segment, 4 cross-sectional images are taken at 0 to 180, 45 to 225, 90 to 270, and 135 to 315 degrees, respectively. The Anterior Segment Double takes images at preset angles of 20 to 200 and 160 to 340. In the Single mode, only a single image will be obtained at the desired angle.

In all modes, the angle of image capture can be changed. In the Double and Quad modes, the preset angle separation will remain the same. Therefore, when manually changing the angle of image capture, all angles will rotate together. For example, if an image is being obtained in the Anterior Segment Quad and the operator adjusts the angle by 15 degrees, the new images will be captured at 15 to 195, 60 to 240, 105 to 285, 150 to 330. All images have been rotated by 15 degrees and are still separated by 90 degrees.

**MEASUREMENT TOOLS**

There are different tools available for measurement, depending on which mode the image was captured in.

In any of the High-Resolution Cornea modes, you can apply thickness calipers, a flap tool, or annotation. The flap tool is composed of a caliper that automatically places itself on the boundaries delineating anterior/posterior surfaces of the cornea with a movable marker in-between to be placed at the flap/stroma interface by the operator.

The Pachymetry map (Fig. 2) is generated from multiple cross-sectional scans taken at different angles. Again, the program software calculates or finds the anterior/posterior surface of the tomographs then interpolates the thickness between adjacent tomographs.

Images captured in the Anterior Segment mode can be analyzed with thickness calipers, angle tools, and anterior chamber depth/width measurements.

**EXPORTING EXAMINATIONS**

Exporting images for presentation is straightforward and simple. After the image has been analyzed, it can be exported in the following process:

File > Export Examinations > Presentation

The image will be saved in JPEG format. All files can be transferred from the Visante either by CD/DVD.
FIGURE 3. Pachymetry map: Fuchs endothelial dystrophy.

FIGURE 4. Anterior chamber with depth and width measurement tools. Such tools can be useful in planning phakic intraocular lens implants.
burner or USB Key. Alternatively, the Visante can be
integrated to a wireless network.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure5}
\caption{Phakic anterior chamber intraocular lens positioning.}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure6}
\caption{High-resolution images of the cornea and the flap tool allow for planning of enhancements.}
\end{figure}

\section*{Strengths and Clinical Applications}

In its clinical application, the Visante is excellent at imaging the anterior segment. Primarily, it provides detailed examination of the structures anterior to the iris, with the following being a list of some of the strengths...
and clinical applications in which it provides useful information.

1. Noncontact instrumentation
2. Quick—no longer than 2 minutes from when the patient sits down
3. Repeatable and reproducible
4. The ability to use measurement tools such as:
   a. Angle tools to measure any angle
   b. The Anterior Chamber Depth/Width tool
   c. Calipers to measure thickness

**FIGURE 7.** One week postoperative in a patient who underwent Descemet stripping endothelial keratoplasty. Note that the graft tissue is completely attached and in good position.

**FIGURE 8.** Four weeks postoperative in the same patient who underwent Descemet stripping endothelial keratoplasty. Note that the corneal tissue and graft tissue are less swollen.
d. Flap tools to measure LASIK flaps and residual stromal beds

5. Image through an opaque cornea
   a. Useful in graft situations
   b. Limited only by pigmented tissues

6. Pachymetry, for example:
   a. Keratoconus
   b. Fuchs endothelial dystrophy (Fig. 3)

FIGURE 9. Moderately narrow angles; preperipheral iridotomy.

FIGURE 10. Same patient as in Figure 9, moments after peripheral iridotomy.
c. Glaucoma
d. Postoperative monitoring of corneal procedures

7. Anterior chamber intraocular lenses
   a. Planning—anterior chamber depth and width can be measured (Fig. 4)
   b. Monitor placement and position postoperatively (Fig. 5)

8. Corneal refractive surgery (Fig. 6)
   a. Corneal thickness
   b. Flap thickness and residual stromal bed

**FIGURE 11.** When assessing narrow angles, it is useful to judge the location of the scleral spur for reference.

**FIGURE 12.** Angle closure glaucoma. The angle is completely closed, and the cornea is noticeably edematous.
9. Endothelial keratoplasty
   a. Attachment of graft (Fig. 7)
   b. Placement of graft
   c. Monitor swelling and resolution (Fig. 8)

10. Narrow angles (Figs. 9–11)
   a. Accurate measurement of narrow angle
   b. Diagnostic images of angle closure (Fig. 12)

11. Tilted intraocular lens implants

   Anterior chamber intraocular lenses are better visualized in OCT coloring when analyzing images.

   The longer it has been since the original surgery, the less distinct the division between flap and residual stroma.

   FIGURE 13. Tilted posterior chamber intraocular lens pushing iris forward.

   FIGURE 14. Iris pressed up against the endothelium of the cornea in complete angle closure. This image was extremely useful in patient education.
a. Although imaging through the iris is impossible, iris displacement gives information as to the misalignment of a posterior chamber intraocular lens (Fig. 13).

12. Patient education (Figs. 14, 15)

13. Research

a. The research that can be performed is only limited by the researcher’s creativity, image resolution, and tool selection.
b. Comparative studies of pachymetry, flap thickness of different microkeratomes, and anterior chamber depth measurements were performed during our trial period. In our comparative study of pachymetry, 34 eyes were measured 3 times each with the Visante and an ultrasound pachymeter. The Visante was found to give average pachymetry readings 19.8 microns less than ultrasound pachymetry, with a $P < 0.001$ (Fig. 16).

- **WEAKNESS**

1. The Visante OCT uses 1310-nm infrared wavelength light

a. Cannot penetrate through pigmented tissue

**FIGURE 15.** Postoperative of patient in Figure 14. Note iris cyst. Because the cyst is anterior to the pigment epithelium of the iris, it can be visualized.

**FIGURE 16.** A short comparative study measuring central corneal thicknesses using the ultrasound pachymeter and the Visante OCT. Note that the Visante pachymeter map underestimates the central thickness by an average of 20 microns.
b. Cannot image anything past the posterior pigmented epithelium of the iris. This can be noted in Figure 13. It would be interesting to note the position of the posterior chamber intraocular lens and how it is truly affecting the iris.

2. Seemingly slow rate of refresh
   a. Being a dynamic image, the computing software has to “catch up” at times, freezing the image on the operator’s screen. This always seems to happen just when the operator wants to capture another image.

3. Software
   a. Limited number of tools
   b. The inability to use the angle tool in High-Resolution Cornea mode
   c. Inability of the software to determine anterior and posterior surfaces of the cornea
      i. Occasionally, time-consuming manual adjustments of the markers indicating the corneal surfaces must be made
   d. There are no built-in analytical tools. It would be useful to have:
      i. Software to analyze pachymetry maps
      ii. Software that automatically finds an angle measurement and indicates “narrow angles” to a technician
   e. No keratometry/radius of curvature readings

4. Higher magnification would be helpful. For example, it would be useful to image:
   a. Epithelium
   b. Endothelium
   c. Trabecular meshwork

We have been informed by the company that many of these issues are under consideration for improvement.

CONCLUSIONS

How does this piece of equipment change or add to our clinical practice? This was one of our key questions in assessing the Visante OCT. In almost all scenarios during our month-and-a-half trial, we found that the Visante OCT provided excellent supplemental information. The Visante OCT was extremely useful in determining residual stromal bed for the purposes of LASIK enhancement and monitoring cases of endothelial keratoplasty. The reason this technology seems to have limited application is because the anterior segment can be easily viewed with a slit lamp. For example, imaging by the Visante OCT did not change our approach to a patient with narrow angles; it confirmed our diagnosis.

What would make the Visante OCT better? The Visante OCT could be enhanced with software updates. For example, software that would automatically analyze angles, indicating to a technician that they are narrow. Other potential areas of development include the use of chemical markers dropped on the cornea in a suspension or solution that would attach to certain tissues or pathogens. This area would then become illuminated in the images taken by the Visante. In addition, it would broaden the application of the instrument if it could be combined with technologies that would allow images to be captured behind the iris.

In summary, the Visante OCT is a fascinating and interesting machine that is worth investigating. Depending on the practice type and focus, the instrument could be very useful.

REFERENCES