I have performed more than 2,000 wavefront LASIK procedures during the last 3 years with the Technolas 217z Zyoptix System (Bausch & Lomb, Rochester, NY), LADARVision CustomCornea wavefront-guided system (Alcon Laboratories, Inc., Fort Worth, TX), and Visx CustomVue wavefront excimer laser system (Visx, Inc., Santa Clara, CA). Although I still have access to all three, I currently use the Visx CustomVue system to perform 99% of my wavefront LASIK procedures. In my opinion, the Visx CustomVue wavefront system provides excellent results and is the most efficient of the available platforms.

RESULTS
Early in my experience with the Visx CustomVue system, it became evident to me that the platform tended to produce small undercorrections. Since then, nomogram revisions made with the physician-adjustment feature in the wavefront planning software have allowed me to fine-tune my results. Data from the WaveScan (Visx, Inc.) examination with slightly more cylinder than the manifest refraction and an axis within 10º of the manifest refraction are my selections to drive the treatment. The spherical component of the WaveScan refraction is refined with the physician-adjustment feature so that it matches the cycloplegic sphere. This technique provides excellent results and almost eliminates undercorrections.

My 3-month follow-up data using the physician adjustment found that I achieve 20/20 or better UCVA in 83.1% of conventional LASIK eyes (n=162) versus 97.5% of the CustomVue LASIK eyes (n=53). These results were similar to

Figure 1. The changes in BCVA at 3 months indicate that the customized LASIK procedure (white) demonstrated a greater overall improvement in BCVA than did conventional LASIK (yellow).

Figure 2. The changes in preoperative BCVA at 3 months when compared to postoperative UCVA indicate that the customized LASIK procedure (white) yielded a greater improvement than conventional LASIK (yellow).
those presented by Steven Schallhorn, MD, from the Naval Medical Center, San Diego, at the 2004 ASCRS annual meeting1 (Figures 1 through 4). Dr. Schallhorn’s study involved a comparison of conventional LASIK (908 patients) versus customized LASIK (34 patients) using multiple wavefront platforms. With conventional LASIK, 88% of patients achieved 20/20 or better UCVA; 97% of the wavefront-guided LASIK subjects achieved 20/20 or better UCVA.1 Similarly, in this Navy study, 69% of patients who underwent conventional LASIK versus 85% of those receiving wavefront-guided LASIK had 20/16 UCVA postoperatively. Additionally, 30% of conventional LASIK patients reported an increase in night-driving halo symptoms compared with no patients in the wavefront-guided LASIK group. After 3 months, the majority of nighttime halo problems abated for the conventional LASIK group. The increase in the rate of patients achieving 20/20 UCVA and the improvement in their quality of night vision have allowed my centers and colleagues to justify a price premium of $500 per eye for CustomVue LASIK.

EFFICIENCY

The efficiency of the Visx CustomVue system is largely due to the elimination of the pharmacological dilation

### REFRACTIVE SCENARIOS ADDRESSED WITH THE CUSTOMVUE SYSTEM

1. A 23-year-old male aeronautical engineering graduate student seeking refractive surgery has manifest refraction of -5.00 -2.00 X 170 for 20/15 OD and -5.50 -2.25 X 175 for 20/15 OS. Pachymetry readings are 510 µm OD and 505 µm OS and his pupils are 8.5 mm OU. How would you proceed?

   Expectations can be excessive in patients of this vocation, so that is the first issue to evaluate. Although pupil size has not been associated with night vision disturbances when laser optical zones are at least 6 mm or greater in any study, I am not convinced that the malpractice lawyers are conceding defeat quite yet. For that reason, I will not perform LASIK on any patient who has a pupil size recorded as greater than 8 mm, even though they would likely have an excellent outcome. In this case, I would recheck the pupils to make sure the first measurement was not too generous. I would also evaluate the Orbscan (Bausch & Lomb, Rochester, NY) topography, because the prescription is relatively high whereas the corneal thickness is relatively low. If the pupils turned out to be 8 mm or less with normal Orbscan measurement and with reasonable patient expectations, I would proceed with bilateral LASIK using the CustomVue system (Visx, Inc., Santa Clara, CA) with intraoperative pachymetry after advising the patient that an enhancement may not be possible.

2. A 54-year-old female transcriptionist with +1.50 D sphere for 20/20 OU and +1.75 D for 20/20 OS seeks refractive surgery. Her right eye is dominant. The patient has successfully worn monovision soft contact lenses but demonstrates increasing contact lens intolerance. Pachymetry measures 560 µm OD and 550 µm OS. Her pupils measure 5.5 mm OU. How would you proceed?

   This patient appears to be a good candidate for monovision LASIK. I would ask which eye she uses for reading with contact lenses. This would likely be her left eye because her right eye is dominant. The reverse is possible, however.

   Next, I would find out what monovision power she has been using. Finally, I would ask for her evaluation of the monovision she had with the contact lenses to determine if she liked it, to find out whether the reading power were adequate, and to evaluate her expectations for the procedure. Although adjustments may be required, with this patient, I would typically correct her right eye for +1.50 D, correct her left eye for +3.25 D, and leave 1.50 D of reading to add. I would use the S4 laser (Visx, Inc.) set with a 6-mm optical zone and 9-mm blend zone, and I would carefully adjust the centering of the correction if the patient had a large angle kappa.

3. A 30-year-old male sales representative seeks refractive surgery. He is contact lens intolerant. Rigid gas permeable lenses were suggested, but he could not become comfortable with the fit, despite achieving excellent clarity of vision. His BCVA is -3.50 -1.00 X 180 for 20/15 OD and -3.25 -1.50 X 175 for 20/15 OS. Pachymetry measures 530 µm OD and 535 µm OS. His pupils measure 6 mm OU. Topography shows bilateral asymmetric bowties. There is a superior/inferior discrepancy of 1.80 D OD and 2.00 D OS. Retinoscopy is regular without scissors. How would you proceed?

   Any asymmetry on topography is a bad prognostic sign for LASIK. I would obtain Orbscan images to further evaluate his corneas. Rarely, the Orbscan can be reassuring if the topography was in a 0.50-D sliding scale that gives the color map a dramatic appearance, even in normal eyes. More commonly, however, the Orbscan will show further asymmetry in the corneas with posterior ectasia or asymmetrical thinning. Refractive surgeons for cases like these have suggested surface ablation; however, if there were significant asymmetry on the topography and Orbscan, I would not perform any corneal refractive procedure.
step necessary with the other FDA-approved wavefront ablation platforms. This step adds a tremendous amount of time to the wavefront measurement process, thus making the process inefficient for the surgeon and inconvenient for the patient. The Visx CustomVue system requires wavefront testing (10 minutes) followed by wavefront selection and processing (10 minutes), which I have been able to incorporate into my surgery day without adding staff or decreasing the number of patients I treat per hour. The LADARVision4000 with CustomCornea wavefront-guided system requires an undilated capture (3 minutes), followed by dilation (45 minutes), the placement of corneal alignment marks (5 minutes), and wavefront testing (15 minutes). In order for the CustomCornea system to be effective, one staff member must be dedicated to wavefront testing on surgery days. The Technolas 217z Zyoptix system requires mild dilation of the eye (10 minutes) before the wavefront capture (10 minutes). However, the Zyoptix treatment is performed on an undilated pupil, so same-day procedures cannot normally be performed. In my experience, because many patients elect customized LASIK on the day of surgery, the possibility of same-day conversion to customized LASIK is desirable (Table 1).

Surgical efficiency differs between the three systems. It is my belief that ablation times should be as short as possible to avoid variations in stromal dehydration during the ablation process. The variable spot-scanning ablation pattern with the CustomVue system has the shortest treatment times of the three FDA-approved wavefront platforms, with the average treatment taking less than 40 seconds.

**UPCOMING IMPROVEMENTS**

The CustomVue system could be further improved in several ways. Although some surgeons have been performing wavefront enhancement procedures, I have been conservative in this area, because the Zernike wavefront assessment was not designed for highly aberrated eyes. Visx, Inc., just received FDA approval for a new WaveScan software upgrade in June 2004; it uses a proprietary Visx Reconstruction Algorithm in all wavefront ablations and is based on a Fourier analysis. This method uses all the lenslet array data so that the derived wavefront shape is a more accurate characterization of the actual wavefront than was previously possible with the Zernike wavefront assessment. This change should allow for a more reliable treatment of complex aberrations.

The clinical significance of the advantages of peripheral wavefront data acquired with dilated wavefront analysis is controversial. Competing companies, however, view the lack of a dilated wavefront map on the WaveScan system as a weakness. Because the new WaveScan software permits acquisitions of WaveScan data out to 7 mm, surgeons will be able to perform peripheral wavefront assessments of patients with large scotopic pupils.

Although the treatment times for the CustomVue system are the quickest of the three main lasers, I believe that even faster ablations would minimize variable stromal dehydration during the ablation. The recently FDA-approved WaveScan software also automatically increases the maximum frequency of the variable spot-scanning ablation, with a variable repetition rate to be...
increased from 10 to 20 Hz, which should further decrease ablation times. Meanwhile, Visx, Inc., has shown that this increased repetition rate has not changed the thermal effects of the excimer beam on the cornea.2

The new WaveScan software also incorporates a 4.5% increase in the CustomVue treatment plan to reduce the need for the surgeon adjustment from the wavefront surgical planning, which will increase clinic flow and efficiency. However, with this boost, it is important that surgeons reassess their nomograms.

Although the eye tracker on the Visx laser is effective, it is currently unable to detect cyclotorsional movements of the eye that can occur when the patients go from the sitting to the prone position. Later this year, Visx, Inc., will introduce an upgrade to its S4 laser that will allow cyclotorsional registration by the identification of prominent iris landmarks (Figure 5).

Finally, the current FDA approvals for CustomVue allow treatments of up to -6.50 D of myopia and 3.50 D of astigmatism, a range that limits the number of candidates for customized LASIK to approximately 75% of the patients who come to my office for evaluation. The FDA approvals for customized corrections of hyperopia and mixed astigmatism are expected by the end of 2004, although high myopia approval is expected in early 2005.

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2. Unpublished internal data, Visx, Inc.

**TABLE 1. A COMPARISON OF THE TIME REQUIRED FOR EACH STEP OF A WAVEFRONT PROCEDURE USING THREE FDA-APPROVED PLATFORMS**

<table>
<thead>
<tr>
<th>Step</th>
<th>Visx CustomVue</th>
<th>Alcon CustomCornea</th>
<th>Bausch &amp; Lomb Zyoptix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquire Centration Images</td>
<td>-</td>
<td>3 minutes</td>
<td>-</td>
</tr>
<tr>
<td>Pharmacological Dilation</td>
<td>-</td>
<td>45 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Corneal Marking</td>
<td>-</td>
<td>5 minutes</td>
<td>-</td>
</tr>
<tr>
<td>Wavefront Examination Acquisition</td>
<td>10 minutes</td>
<td>12 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Surgeon Planning of Wavefront Ablation</td>
<td>10 minutes</td>
<td>10 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Average Wavefront LASIK Procedure Time</td>
<td>7 minutes</td>
<td>8 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Total Additional Time for Wavefront Procedure</td>
<td>27 minutes</td>
<td>83 minutes</td>
<td>40 minutes*</td>
</tr>
<tr>
<td>When Can Wavefront Data Be Acquired for Driving Wavefront Procedure?</td>
<td>Surgery day or before</td>
<td>Surgery day only</td>
<td>Before surgery day only</td>
</tr>
</tbody>
</table>

*Wavefront acquisition and LASIK procedure must be performed on separate days.

**Figure 5. The CustomVue rotational eyetracker allows cyclotorsional registration by the identification of prominent iris landmarks.**