Pupillometry and the Procyon P3000

Michelle Hanratty puts a new pupillometer through its paces

The Procyon series of pupillometers has been long recognised as the Rolls Royce of pupillometers and there is literature evidence to show that the accuracy and repeatability of the instrument exceeds that of its competitors.[1,2] So as Procyon launches its latest pupillometer onto the market with a recommended retail price of £5,500, you might wonder who it is aimed at and where the need for such an instrument might arise.

Figure 1 The Procyon P3000 Pupillometer

Refractive surgery planning

The most obvious need is in the field of refractive surgery where a pupil measurement is required to determine the desired optic zone of the treated eye. In laser refractive surgery, the treatment zone that a surgeon can choose is within 100ths of a millimetre so it is logical that the pupillometer should match the degree of measurement. It has been recognised by the refractive surgery community that the greater the pupil size, the greater the risk of night-time glare problems postoperatively,[3,4,5] but there is no definite cut off point at which surgery is contraindicated. This is because the causes of glare are multifactorial and the risks are now greatly reduced thanks to the advent of aspheric laser ablation profiles which are designed to optimise quality of vision and the narrow beam lasers which are able to create smoothly blended transition zones on the cornea. However, in order to apply this technology effectively, the surgeon does need an accurate pupil measurement.

When a single pupil measurement is taken, we gain information about the pupil size at that given moment in time. In the case of refractive surgery, it is helpful to know how the pupil behaves in different lighting conditions and to know what the maximum pupil size would be. This helps to ensure that there are no sharp edges to the optic zone within the pupil margins. Knowing the pupil size to a high degree of accuracy can also influence the suitability of the patient for treatment, as a larger pupil requires a greater diameter treatment which in turn requires an increased depth of ablation.

Refractive lens surgery is also an increasingly popular option among those patients whose prescription or lens condition precludes them from having Lasik or Lasek. Intraocular contact lenses and multifocal intraocular lens implants are often used in these patients and an accurate pupil measurement will increase the likelihood of a good outcome. Although there are no published data of the optimum pupil size in relation to the intraocular lens optic size, there may be an increased risk of glare problems if the optic zone edge falls within the pupil margin. There is a variety of multifocal IOL implants available and they work by either using the ciliary muscle to shift or bend the IOL to change focusing power, or by diffraction. The latter is particularly dependent upon pupil behaviour in different light conditions.

Counselling the refractive surgery patient

As well as providing data for use in surgery, the pupil information gathered can help the surgeon to judge the susceptibility of the patient to night-time glare problems and to council the patient appropriately. Quite often, a patient with large pupils may have haloes and starburst at night before surgery but not be aware of it and it is only after careful questioning by the surgeon that the patient realises the issue exists. Failure to discuss and document existing glare issues may lead to the patient only noticing it after surgery and when it does not disappear completely with time, they mistakenly believe that the residual glare is due to surgery and become discontented with the outcome. Identification of those patients at an increased risk of developing glare problems at night is essential to manage patient expectation successfully.

Other uses

Pupil assessment is an important test carried out by clinicians daily and the ability of the clinician to make an accurate assessment can be a matter of life and death, but is a quantitative pupil measurement actually that important? In assessing pupil responses to light, it is the swinging flashlight test that is most sensitive and most relied upon. However, measurements of the pupil in scotopic and mesopic light may help to determine whether a patient has a physiological anisocoria or a pathological condition.

Research

Binocular pupillometry can be used to investigate the effect of drugs on the ▶

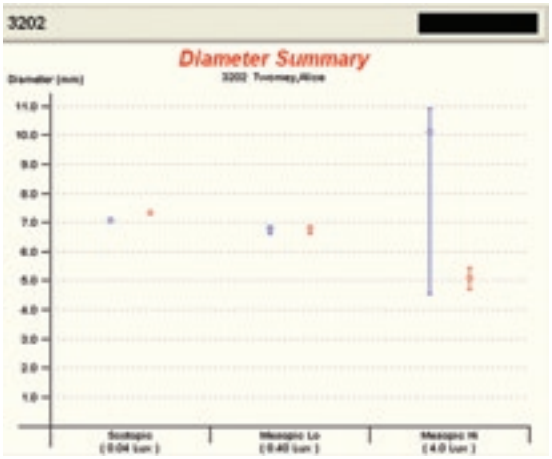

Figure 2a The average measurement and spread of values

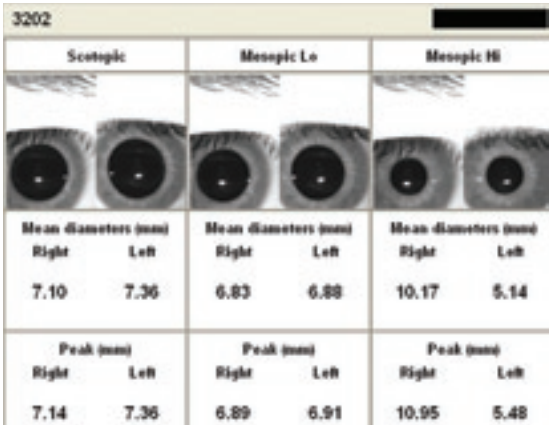

Figure 2d Final results are presented in a summary table

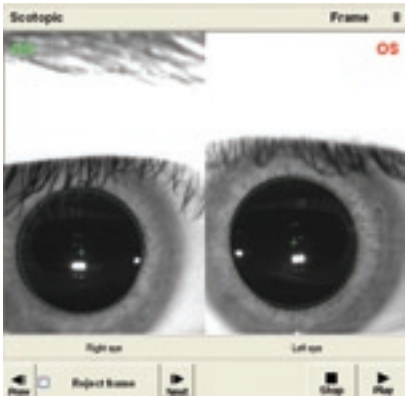

Figure 2b

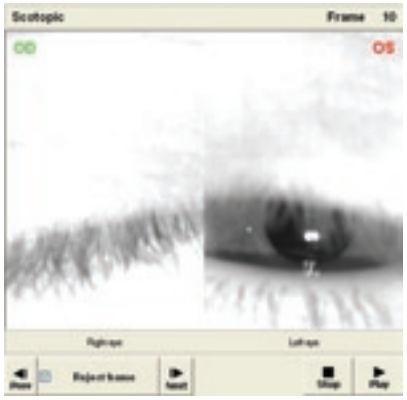

Figure 2c

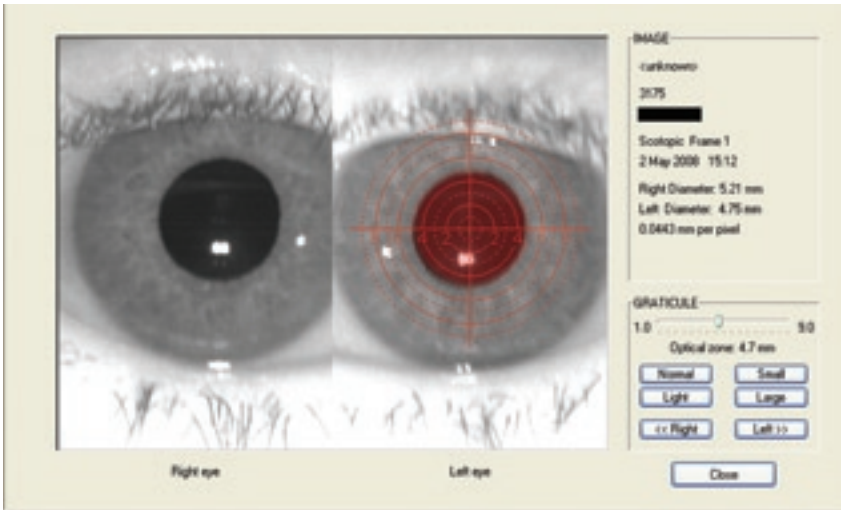

Figure 2e Operator-controlled measurement graticule

pupil response and has also been used in psychology research to investigate the effect of fear on pupil behaviour. Researchers at Nottingham University used the fear of an electric shock to monitor the resultant dilation of pupils and the reduced amplitude of light response.[5] Another group based in Crete used the pupillometer to better understand the autonomic mechanisms behind these two features of pupil behaviour and why only the fear-induced light response and not initial pupil dilation was affected by drugs such as diazepam.[6] The research team concluded that the first response was likely to be a result of central parasympathetic innervation and the latter response due to central sympathetic excitation.

Opioid dependency testing

Another interesting application of pupillometry has been carried out at St George's Hospital in London.[7,8] An opioid dependent subject can be identified by the positive pupil dilation seen in response to conjunctivally applied naloxone hydrochloride. This test was evaluated in an opioid dependency treatment clinic using a binocular pupillometer and it was found that the test gave positive results in 81 per cent of cases. The results were more likely to be incorrectly negative in males and those not on methadone at the time. The pupillometer increased the number of patients correctly identified as opioid dependent which could be useful when screening new patients or subjects.

The Procyon P3000

The Procyon Pupillometer measurement is carried out in a dark room and the patient is asked to place their head against a rest which excludes external light (Figure 1). The only light that can stimulate the pupil response is that from the pupillometer. The light settings for the pupillometer are carefully calibrated to replicate photopic, mesopic and scotopic light conditions and are presented binocularly to the patient. The accommodative response is controlled by providing a binocular non-accommodative target and there is the facility to compensate for the patient's ametropia if the target appears blurred.

The P3000 takes a mini video of each pupil which consists of 10 individual frames. After all three light responses have been recorded, the instrument's software on a linked computer calculates the average pupil size for each lighting condition and displays a graph showing the average measurement and the spread of values found (Figure 2a). This allows the operator to see at a glance whether or not there was a large variation in the measurements taken. A large variation is not ideal and suggests the computer software was not able to track and then measure the pupil margins accurately. This may be due to poor image quality, irregular pupil shape or perhaps blinking. The operator can then view the recording frame by frame and eliminate those in which the pupil is not tracked by the software, thus ensuring a reliable averaging of the pupil measurements (Figure 2b and c). Once the data has been checked for reliability, the final results are presented in a summary table (Figure 2d) which can be printed and kept in the patient's notes.

Old versus the new

Previous incarnations of the P3000 relied on a video card to record the images onto a computer which were susceptible to damaged connections (easily bumped) and the operating software crashing. The significant frustrations ▶

of having to restart the computer with a patient already in the headrest are a thing of the past, with the P3000 having a faster and more reliable USB connection. This latest model also comes with a operator-controlled measurement graticule (Figure 2e) which can be activated when the computer software does not track the pupil very well. This is a fairly rare occurrence if the patient does not blink and keeps still while the measurements are being taken, but oval pupils can be a challenge. If on reviewing the frames, the operator is not satisfied with the pupil tracking, they can opt to use the graticule function. This allows the operator to select a best-fit measurement sphere so that fits the pupil area instead of using the software generated average.

There have also been improvements with the patient head rest which is more comfortable and positions the patient better for measurement.

P3000 vs Colvard Infrared Pupillometer

Advantages of the P3000 over its more widely used rival, the Colvard pupillometer (Figure 3) are as follows. Measurements are taken under binocular conditions which are more 'real world' than those taken with the monocular infra red Colvard. Research has shown that monocular pupil measurements are significantly higher than binocular ones.[10,11] Measurements taken under three different controlled light conditions also provide a greater amount of information about pupil behaviour, whereas the Colvard is used in a dark room setting only. The Colvard also relies on the operator to subjectively measure the pupil against a millimetre scale, whereas the P3000 objectively generates multiple measurements to the 100th of a millimeter which are then averaged out to minimise the effect of hippus.

The advantages of the Colvard are that it is hand-held and is very portable, which is convenient for wheelchair-bound patients. It is also simple to operate and although the P3000 measurements are fairly quick, the Colvard is quicker because it captures less data and does not store it on a database. There is also a significant difference in price; the Colvard retails at approximately £1,500.

The P3000 also has a high degree of repeatability which is not easily matched by the Colvard. To overcome this, the manufacturer Oasis Medical has issued the following checklist for use:

- Obtain screening room light level of approximately 4cd/m^2. It should be noted that the light level might need to be made darker depending on the lifestyle of the particular patient
- Measure the light level in the room with a light meter
- Wait at least 30 seconds until taking the measurement for full dilation of the pupil
- Once the pupillometer is placed over the eye, instruct the patient to focus on an object at the end of the room with the fellow eye
- Focus the reticule and take the measurement
- Document measurement in patient records
- Repeat process on the second eye.

Figure 3
The Colvard pupillometer

Summary

The P3000 target market is mainly refractive surgery and the latest model improves on what was already a good piece of instrumentation, but was prone to the occasional hardware glitch. The reputation of the Procyon instrument for precision and the repeatability of pupil measurements is well established and the introduction of a graticule may give something extra for those surgeons looking for even greater precision for complex wavefront cases. The ability of the machine to record and review measurements could also make it a very useful tool for research into the pupillary response. ●

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