Editorial

Automated evaluation of the pupil

Exploración automática de la pupila

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The evaluation of the morphology, size and reactivity of the pupil is one of the basic ophthalmological and neurological evaluations. Typically it has been done simply by measuring the size of the pupil with various types of rulers or manual pupil meters with the aid of a source of light for assessing pupil reflexes.

Obviously, said evaluation is subjective and entirely dependent on the skill of the observer. For this reason, recent automatic devices are providing more precise and reproducible measurements of the size and reflexes of the pupil, also facilitating new parameters that are beyond the skill of the observer.

The evaluation of the pupil size is significant in neuro-ophthalmology for differential anisochoria diagnostic. Recently it has acquired special relevance in refractive surgery because some patients refer diverse symptoms in scotopic conditions after the intervention such as halos, monocular diplopia, loss of contrast sensitivity depending on the degree of midriasis. Accordingly, presurgery evaluation has gained importance.

There are several portable monocular pupil meters on the market such as NeurOptics NPI-100 (NeurOptics, Irvine, CA, USA), an infrared portable device that analyzes pupil dynamics in a period of 3 s. By means of a flash it simulates the response to light and records 30 images of the pupil. In this way, the device takes into account the final state of the pupil after the various stages of the motor response (contraction–hippus–redilatation–intermediate contraction). It provides multiple data such as the maximum and minimum size of the pupil, latency, contraction and dilatation speed with mean values and standard deviation (SD). In addition it provides a new index, the neurological pupil index which utilizes a score of 0–5 (5: highest response, 3 or higher: normal reactivity, under 3: abnormal pupil reflex) to provide a reverse correlation with intracranial pressure in patients with increased intracranial pressure. Accordingly it is suggested it could be useful for managing intracranial hypertension patients, thus extending its scope to intensive care units and neurosurgery.1

Another device, NeurOptics PLR-200 (NeurOptics, Irvine, CA, USA)2 is more focused on neuro-ophtalmology and refractive surgery. It also takes 30 readings in the course of 3 s, excluding extreme readings and calculating the measure and SD. Inter-device reproducibility is very high (−0.094 ± 0.12), with intra-observer reproducibility also being very high. Bradley et al. have studied normal scotopic pupil ranges based on patient age and developed a database. The diameter diminishes and remains in the area of 7 mm in the first decade of life and at age 60–69 it diminishes to about 5.5 mm. It is unusual to find a scotopic pupil under 6 mm in patients under 36 years of age. The disadvantage of this device is that it sometimes fails to assess larger pupils (over 8 mm) and has difficulties in identifying the pupil edge in patients with dark iris.3

One of the most widely used devices due to its lower price is the Colvard pupil meter (Oasis Medical, CA, USA). This is a monocular portable device with a millimeter scale which also uses infrared technology. The operator focuses the pupil with forward and backwards movement while the patient fixes

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on an internal red light, similar to a direct ophthamcoscopy device. The other eye is covered to prevent miosis due to convergence. The device has a millimeter rule with a precision of 0.5 mm overlapped on a grid, allowing direct reading by the operator. Measurements with a precision of 0.1 mm are not possible and therefore the values are interpolated (for instance, 5–5, 25–5.5). This device has a learning curve and therefore requires an expert operator.  

Yet another device, Procyon P3000 (Procyon Instruments Ltd., London, United Kingdom) is an infrared digital binocular device which allows the simultaneous reading of both pupils. The patient gazes a black stimuli point which is virtually focused at 10 m. The device comprises covers that isolate the eyes from external lighting. The infrared diodes provide lighting to the eyes without influencing the pupil response.  

It has 3 levels of luminance (0.04, 0.4 and 4 lux) and the device obtains a sequence of 10 images in 2 s for each level simultaneously in both pupils. The device provides mean values, range and SD. With this device the operator plays an important role because the devices must be centered and focused with precision.  

It enables the detection of the relative afferent pupil defect (RAPD) when there is a difference of 0.3 logarithmic units.  

As is the case with other technologies, the values obtained by different devices are not interchangeable. Of the 3 devices described above, the most observer dependent is the Procyon pupil meter whereas for some the NeurOptics device exhibits the higher interobserver matching. However, other authors find low variability with the Procyon device.  

In addition to the above devices, there are pupil meters coupled to other devices such as autorefractometers or corneal topographers. The results obtained by these devices are also significantly different from those obtained with said devices. Moreover, ambient lighting influences the readings. This is a drawback as these devices have more difficulty in offsetting ambient lighting than classic pupil meters and therefore are less recommendable for studying mesopic pupils prior to refractive surgery.  

An additional potential application of automatic pupil meters is the assessment of RAPD, a key sign in diagnosing monocular or asymmetric visual field pathway pathology. Clinically, the evaluation is made with the alternating light test, which is completely observer dependent and therefore slight degrees can go unnoticed to inexperienced operators. Even though the RAPD can be measured with a neutral density filters, these are rarely available and therefore in general the intensity thereof is assessed subjectively and therefore not reproducibly. The minimum degree of RAPD which can be detected by expert operators with the alternating lighting test is of 0.3 logarithmic units.  

All the above considerations have prompted the quest for automatic objective methods that provide quantitative and reproducible pupil response readings. The most widely studied devices in the market are the Procyon P3000 infrared digital pupil meter (Procyon Instruments Ltd., London, United Kingdom) and RAPDx (Konan Medical, USA). The former has demonstrated high sensitivity and specificity together with significant reproducibility in evaluating RAPD induced with neutral density filters.  

In turn, RAPDx is a computerized binocular pupil meter which was recently given the CE label, for which reason there are no studies on this device in scientific literature although the first publications reported in ophthalmological meetings are very promising. This device analyzes the pupil response to various types of stimuli and light intensities, including colors, and provides multiple data such as latency and pupil response amplitude. A peculiarity of this device is that the data are integrated in a universal database through a virtual cloud from where a report is issued. This means that Internet connection is required. Initial studies have noted that the device is able to discriminate patients with glaucoma from healthy subjects with high sensitivity and specificity. For this reason, its use for glaucoma screening test has been suggested (Chang et al. detecting glaucoma with pupillography, ARVO 2012, Fort Lauderdale, USA).  

In summary, there is a range of automatic monocular and binocular pupil meters. The portable monocular devices are highly reproducible and have the advantage of lower cost. However, they are unable to evaluate RAPD. The new computerized binocular devices are able to analyze with precision a number of parameters of photomotor reflexes which escape the subjective assessment of an operator although they are larger and more expensive.

REFERENCES