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# Ciliary body imaging with transpalpebral near-infrared transillumination – a pilot study

## *Obrazowanie ciała rzęskowego za pomocą przezpowiekowej transiluminacji światłem podczerwonym – badanie pilotażowe*

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**Abstract:** Background: Near-infrared light is known to pass through human tissues better than visible light. With invisible infrared light, the eye can be illuminated not only through the cornea or the sclera, but also through the eyelid, which can be beneficial in some cases.
Purpose: To determine possible use of near-infrared radiation in visualizing ciliary body structures by transpalpebral transillumination.
Material and methods: The study cohort included 15 people (30 eyes) with no visible lesions of the anterior segment of the eye; 20 patients (20 eyes) with absolute glaucoma before the laser transscleral cyclodestruction; and 15 patients (15 eyes) with intraocular tumours of the ciliary body. In all cases, a color photo of the anterior eye segment, infrared transillumination and ultrasound scan were performed.
Results: In healthy individuals and in patients with absolute glaucoma prior to laser cyclodestruction, a ciliary body and its structures were imaged. In patients with intraocular tumours, near-infrared transillumination made it possible to visualize the tumour and to estimate its localization relative to the ciliary body structures.
Conclusion: Transpalpebral near-infrared transillumination accurately estimates the projection of ciliary body structures to the sclera. Near-infrared transillumination can be used for ciliary body visualisation in patients with absolute glaucoma prior to laser cyclodestruction. Near-infrared transillumination helps visualize intraocular tumours and determine their projection to the sclera, which can be used for diagnostic purposes and during destruction of the tumour.
**Key words:** Near-infrared light, ciliary body, transillumination.

Transillumination of the eye in visible band of electromagnetic spectrum enables visualising shadows in projections of intraocular structures. Transillumination technique is commonly used as an aid to determine the location of the ciliary body, intraocular tumours or cysts. Intraoperative transillumination is also used to ensure correct placement of the radioactive plaque during episcleral brachytherapy in patients with uveal melanoma (1,2). In 1933, Dekking first published a paper on the use of near-infrared light (NIR) light in ophthalmology (3). Being a potential source of additional information on ocular structures, infrared visualization has not been sufficiently developed and investigated yet. Further research and development of the NIR emitting sources and receiving devices opens new possibilities for the non--invasive digital visualization of the intraocular structures (4–6). Application of visible light assumes transcorneal or transscleral transillumination of the eye. It is known that the NIR light passes through human tissues better than the light of visible spectrum. With invisible infrared light, the eye can be illuminated not only through the cornea or the sclera, but also through the eyelid, which can be beneficial in some cases (7).

### Purpose

To determine possible use of near-infrared radiation in visualizing ciliary body structures by transpalpebral transillumination.

### Material and methods

The study cohort included 15 people (30 eyes) with no visible lesions of the anterior segment of the eye; 20 patients (20 eyes) with absolute glaucoma before laser transscleral ciliary body destruction; and 15 patients (15 eyes) with intraocular tumours located in the ciliary body. In all cases, a color photo of the anterior eye segment, NIR transillumination, and ultrasound imaging were performed.

The device for NIR transillumination was developed together with the Ukrainian Institute of Physics of Metals (7). The system for NIR transillumination consists of a compact wireless infrared LED probe (940 nm wavelength), a monochrome camera (Watec) able to capture video and images in the NIR range, a slit lamp adaptor and a computer with software for viewing and processing the received data (Fig. 1).

Examination is conducted in a dark room using a wireless LED probe for transpalpebral or transscleral illumination with a video camera mounted opposite the test eye. For the transpalpebral transillumination, NIR light diode source with peak wavelength at 940 nm is used. Light radiation from the diode source penetrates into the globe through the eyelid and sclera. Eye needs to be open during the examination. The camera focuses on the anterior segment. A patient is requested to fix their gaze on the fixation mark for convenient imaging. The image


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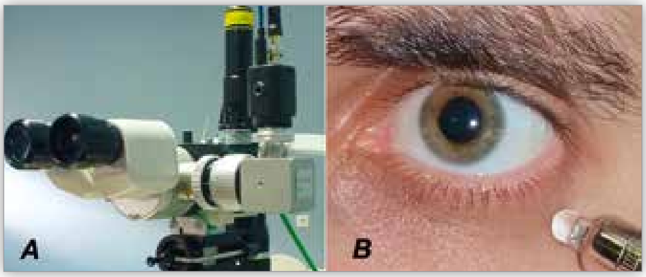


**Fig. 1.** A – the modified slit lamp and camera system for NIR transillumination, B – near-infrared LED probe position during examination.

is displayed on a computer screen and stored in a database. The examination is performed without local anesthesia.

### Ethical considerations

The study was conducted in accordance with the principles of Good Clinical Practice and the Declaration of Helsinki. Institutional ethics committee approval was obtained. Patients were required to provide written informed consent before enrolment in the study and the conduct of any study-related procedures.

### Results

In all healthy individuals, transpalpebral NIR transillumination enabled visualization of ciliary body structures. In all cases, good quality black and white images of the ciliary body structures were captured. Images of the normal anterior segments showed light areas corresponding to the pupil, iris and sclera due to their infrared transmitting properties. In most cases, the NIR transillumination revealed the structural folds of Schwalbe and circular contraction folds on the posterior surface of the ciliary portion of the iris. In some cases, the radial contraction folds were visualized in the pupillary portion of the iris extending from the pupillary margin to the collarette. Dark circle-shaped shadows were clearly visualized against the light background of the iris and sclera (Fig. 2). They represent the projections of intraocular structures, which absorb NIR light more effectively than iris and sclera. The first circular shadow, located near the pupillary edge of the iris is approximately 1.0–1.5 mm wide and corresponds to the pupillary sphincter muscle. The second concentric shadow 1.5–2.0 mm wide is located in the area of the corneal limbus and represents the pars plicata of the ciliary body. The third circular shadow 1.0–2.0 mm wide is visualized in the projection of ora serrata area to the sclera. The pars plana of the ciliary body is visualized as a light wide area with radial well-defined ciliary plicae between the shadow of the pars plicata and ora serrata (Fig. 2).

The width of the pars plana area of the ciliary body is 4.0–4.5 mm. In some cases, a thin dark circle with distinct margins was seen between the corneal limbus and pupillary edge, which represented equatorial border of the lens. Thus, the NIR transillumination made it possible not only to capture the image of the ciliary body, but also to accurately estimate the size of its structures and their projection to the sclera.

In patients with intraocular tumours, transpalpebral NIR transillumination made it possible to visualize the ciliary body and tumour shadows on the sclera as well as to outline their borders. In all cases, the anteriorly located intraocular tumour shadows were detected and tumour location relative to the ciliary body structures was determined. The ciliary body involvement was detected in some cases, which is an established unfavorable prognostic sign (Fig. 3).

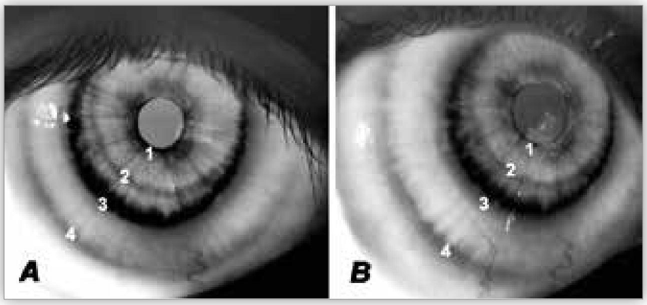


**Fig. 2.** A – NIR transillumination photograph of the right eye of a 35-year-old healthy man. Note the pupillary sphincter muscle (1), the equatorial border of the lens (2), the pars plicata of the ciliary body (3) and the ora serrata (4). B – NIR transillumination photograph of the same eye (oblique view).

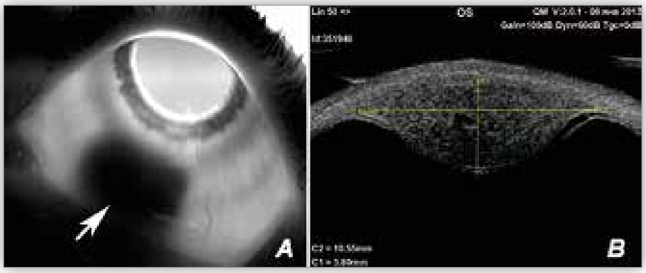


**Fig. 3.** A – NIR transillumination photograph of the ciliary body melanoma located in the lower nasal quadrant of the left eye of a 65-year-old woman. Note the shadow in the projection of intraocular tumour (white arrow) and its contact with pars plicata of the ciliary body. B – ultrasound scan of the same eye in the projection of the tumour.

The pars plicata of the ciliary body was visualized using NIR transillumination in all quadrants of the eye in patients with absolute glaucoma prior to laser cyclodestruction. Direct visualization of the pars plicata in relation to the landmarks on sclera (conjunctival or episcleral vessels) enables precise positioning of the probe during laser coagulation. Ultrasonography can visualise ciliary body processes, determine their localization, sizes and shapes. However, lacking clear scleral landmarks, does not enable accurate positioning of the laser probe in the projection of pars plicata during transscleral laser coagulation.

### Discussion

Saari et al. used the incandescent lamp of the Zeiss slit lamp as a source of NIR light for infrared transillumination of the iris in 2005. A filter was used transmitting only infrared light, which was applied through a long light fiber optic cable onto the temporal portion of the sclera. The technique, though, required a contact of the optic fiber with the anaesthetised sclera (5, 6). In 2013, Krohn et al. presented a technique NIR transillumination-based imaging of intraocular tumours utilising the modifications of a conventional digital slit lamp camera system. They used Canon EOS 30D camera equipped with a modified filter which transmitted the infrared light waves up to 1100 nm in length rather than blocked them, to record the infrared signal. A fiber-optic light probe was placed on the anaesthetised surface of the cornea or sclera.

The flash light, synchronized with the camera shutter, was applied onto the eye through a fiber-optic cable and entered the eye through the cornea or sclera illuminating the intraocular structures (8).

Using the NIR light it is possible to transilluminate the eye not only through the cornea or sclera, but even through the eyelid. This technique offers a number of benefits (7). First of all, the procedure is simple, safe and well tolerated by patients. The proposed technique of transpalpebral transillumination does not require local anesthesia. Thus, potential allergic reaction to local anaesthetics is avoided. The non-contact transillumination excludes the risk of infection or injury to the cornea or sclera. In our study, all imaging procedures were carried out quickly, comfortably and safely.

Using the NIR light emitting diode simplifies the system for eye transillumination. The procedure does not require fiber-optic cable to deliver the light radiation to the eye. The LED source is a compact wireless device, which does not require additional infrared filters. In order to ensure better quality imaging of intraocular structures, different wavelength LEDs (810, 940 nm) can be used. Safety issues in light sources of ophthalmic instruments include photochemical and thermal hazard. The absence of blue portion of the spectrum in the near-infrared LED excludes photochemical damage to the retina during the examination. The radiant power of the near-infrared LED in our study was 60 mW, which is significantly below the limits for thermal hazard (9). Additionally, transillumination of the eye with the near-infrared LED source excludes the irritating and blinding effect of the visible light which was a disadvantage of approaches mentioned above, where light sources of the visible light were used.

NIR transillumination allows visualization of pars plicata of the ciliary body. This technique can be used to ensure accurate positioning of the laser probe during transscleral laser cyclodestruction in patients with absolute glaucoma, as opposed to ultrasound imaging which lacks precise landmarks. Furthermore, NIR transillumination enables detection of intraocular tumour projection to the sclera. Thus, the technique can be used for precise positioning of the laser probe during transscleral laser destruction or transscleral thermotherapy of uveal melanoma. Our technique of NIR transillumination is easilyrepeatable. It makes it possible to monitorprocess dynamics and estimate treatment results. Owing to safety and simplicity of the procedure, the real time transpalpebral NIR transillumination photo and video imaging is now possible at every follow-up visit.

## Conclusion

Transpalpebral NIR eye transillumination provides imaging of the ciliary body and accurately estimates the projection of its structures to the sclera. Infrared transillumination can be used for visualization of the ciliary body in patients with absolute glaucoma prior laser transscleral ciliary body destruction. NIR transillumination, which helps visualize intraocular tumours and determine their projection to the sclera, can be used for diagnostic purposes and for tumour destruction.

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