ophthalmic diseases, clinical cases, lens imaging

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IMAGING OF THE LENSES OF THE HUMAN EYE BY ULTRABIOMICROSCOPY (UBM), ULTRASONOGRAPHY (USG) AND BY ANTERIOR SEGMENT OPTICAL COHERENCE TOMOGRAPHY (AS OCT): - PRESENTATION OF CLINICAL CASES

The nervous system's ability to receive light stimuli and its' processing in the brain in order to produce a visual impression is the definition of the sense of sight. The anatomical form of the sense organ of vision is comprised of the eyeball, the eye's protective apparatus, the eye's movement apparatus and the retinal nerve connections made to structures in the brain. The shape of the eye's lens, which gives the eye its refraction ability, depends on the voltage present in Zinn's ligaments that regulate the ciliary muscle. Sharpness of vision is produced by changing the shape of the lens, a reflexive adjustment. A domed lens causes stronger light inflexion and allows a sharp visual appearance of close objects. A flattening of the lens results in less light refraction and the seeing of more distant objects. The lens consists of a capsule, a cortex and a nucleus and it has two convex surfaces: the front and the rear. If we imagine the lens as a plum fruit, the capsule is its skin, the cortex is its flesh and the nucleus is its stone.

Proper functioning of the lens is essential for accurate vision. Exact assessments of the eye's lens and the ability to monitor the status of associated diseases are extremely important. The lens may be tested using a slit lamp, but in any situation where an eye disease prevents this assessment of the lens this examination will obviously be inadequate. Thanks to today's imaging techniques, we can now assess the anatomical arrangement and condition of the lens, even in the eyes of those patients for whom the use of an imaging lens slit lamp is not possible [1, 2].

The aim of this paper is to review the ocular sonography, ultrasound biomicroscopy and optical coherence tomography examination techniques, especially as they concern imaging of the lens of the human eye.

Today, the best method of imaging abnormalities in most lenses is ultrabiomicrosocpy (UBM). However it is not always possible to undertake UBM due to many centers not possessing the specialized equipment required. There are other tests for lens evaluation, such as ultrasound imaging and OCT, that are more accessible. UBM is a test that supplies images of the eye's anterior segment through the use of ultrasound. Using different frequencies,, dif The nervous system's ability to receive light stimuli and its' processing in the brain in order to produce a visual impression is the definition of the sense of sight. The anatomical form of the sense organ of vision is comprised of the eyeball, the eye's protective apparatus, the eye's movement apparatus and the retinal nerve connections made to structures in the brain. The shape of the eye's lens, which gives the eye its refraction ability, depends on the voltage present in Zinn's ligaments that regulate the ciliary muscle. Sharpness of vision is produced by changing the shape of the lens, a reflexive adjustment. A domed lens causes stronger light inflexion and allows a sharp visual appearance of close objects. A flattening of the lens results in less light refraction and the seeing of more distant objects. The lens consists of a capsule, a cortex and a nucleus and it has two convex surfaces: the front and the rear. If we imagine the lens as a plum fruit, the capsule is its skin, the cortex is its flesh and the nucleus is its stone.

Proper functioning of the lens is essential for accurate vision. Exact assessments of the eye's lens and the ability to monitor the status of associated diseases are extremely important. The lens may be tested using a slit lamp, but in any situation where an eye disease prevents this assessment of the lens this examination will obviously be inadequate. Thanks to today's imaging techniques, we can now assess the anatomical arrangement and condition of the lens, even in the eyes of those patients for whom the use of an imaging lens slit lamp is not possible [1, 2].ferent parts of the lens can be visualized: 80 MHz for the front of the lens; 35-50 MHz for the complete lens [10]. UBM examinations permit measurement of the

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anterior chamber's depth, an evaluation of the iris, the ciliary body, the lens, the presence of angle glaucoma and to a lesser extent an investigation of the cornea and the sclera. Using this test, we can monitor the size of anterior structures including the depth of the anterior chamber, the thickness of the cornea, the iris, the size of tumors, cysts and other pathologies.

UBM supplies an accurate evaluation of the lens' anatomical location and its location in relation to the eye's other anterior segment structures (Fig. 1, Fig. 2, Fig. 3). The use of UBM is especially important when working in the presence of irregularities in corneal opacity and the resulting opacity in the anterior chamber. By utilizing a UBM examination, both the overall extent of lens opacity and the opacity's distribution within the lens can be determined.

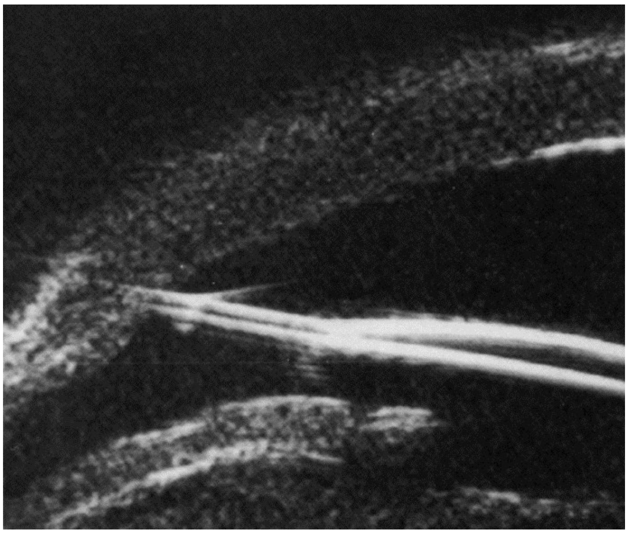

Fig. 1. Dislocation of the lens [3].

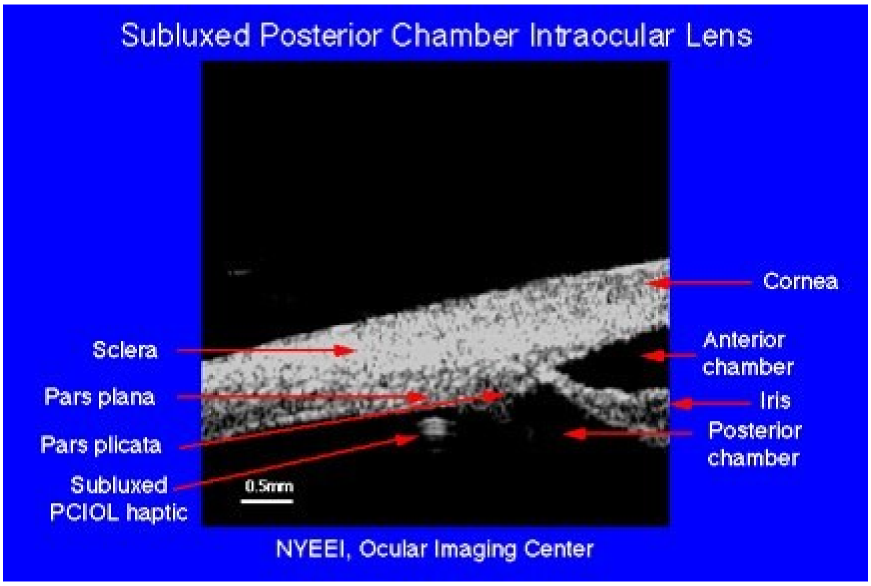

Fig. 2. Subluxed posterior chamber intraocular lens [4].

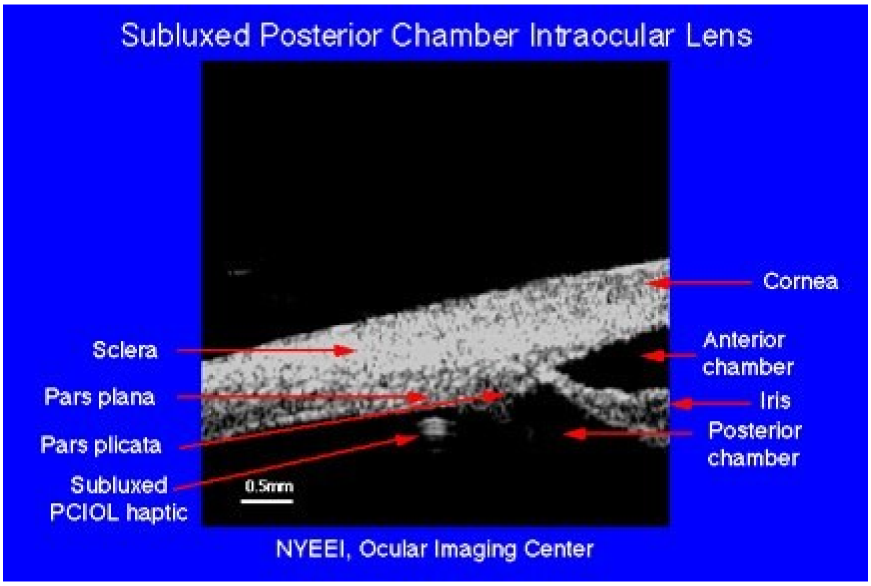

Fig. 3. Subluxed posterior chamber intraocular lens [4].

Ultrasound examinations of the eye are also used to assess the lenses of those patients with one or more cataracts. Given a proper orientation of the eyeball - the right eyeball is temporally directed contrary the patient's nose – the degree and location of opacity within the lens can be assessed (Fig. 4, Fig. 5, Fig. 6, Fig. 7, Fig. 8). The reverse arrangement – (right eyeball is nasally directed) is restricted by difficult access and maneuvering of the globe from the nose. Deep-set eyes also make it more difficult to utilize this approach [2, 5].

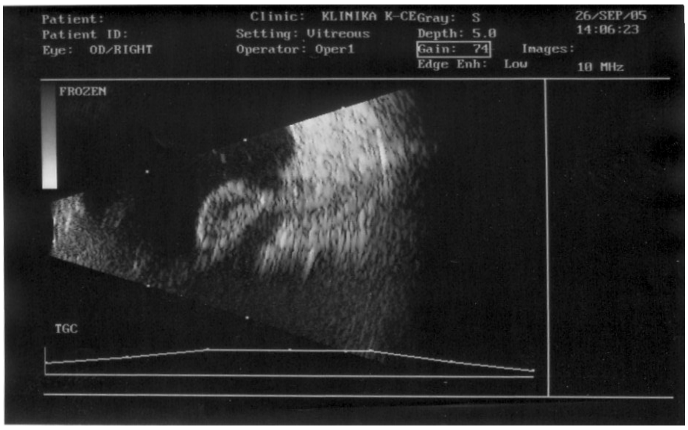

Fig. 4. Mature cataracts: a uniformly expanded saturated echo across the clear part of the lens and thickened lens contours [6].

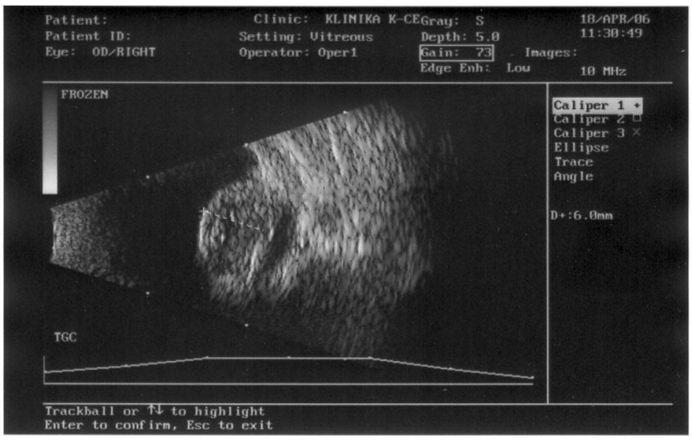

Fig. 5. Intumescent cataracts: the lens echo is larger, a regular echo-structure lens [6].

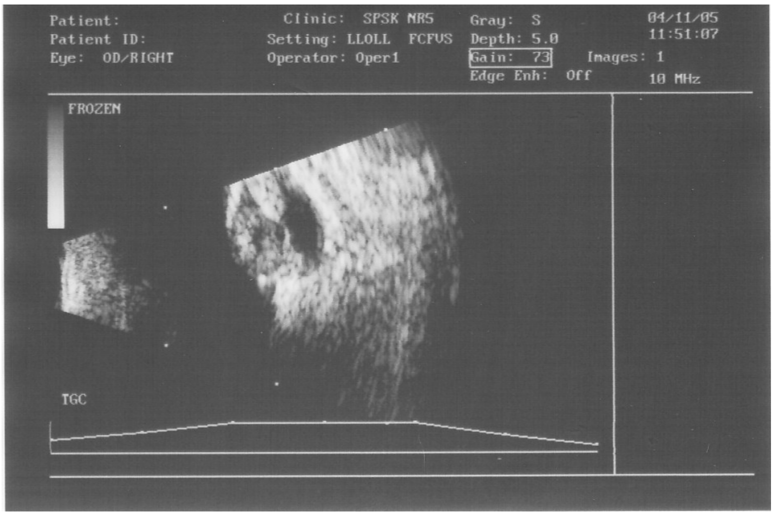

Fig. 6. Cortical cataracts: increased saturation of the lens' cortical layers. The lens nucleus has a low echo, low to medium saturation capsule echo and a subcapsular layer [6].

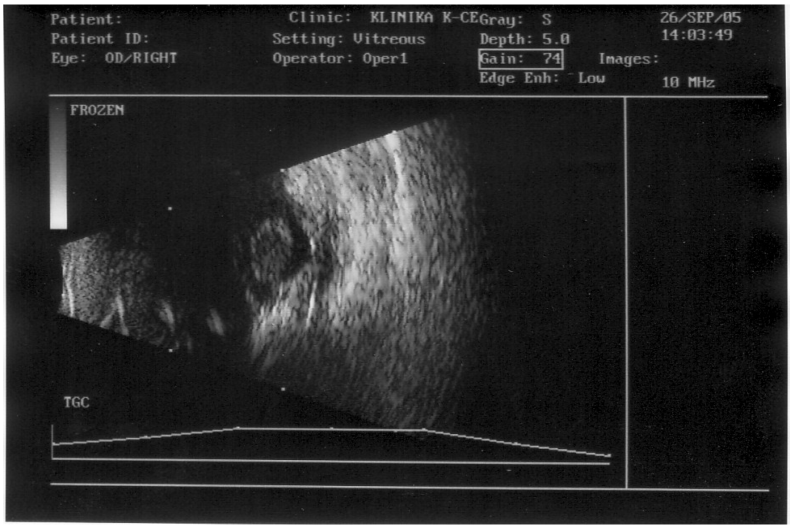

Fig. 7. Nuclear cataract: tall, strongly demarcated echo in the center of the lens; low echoes around the remainder of the lens [6].

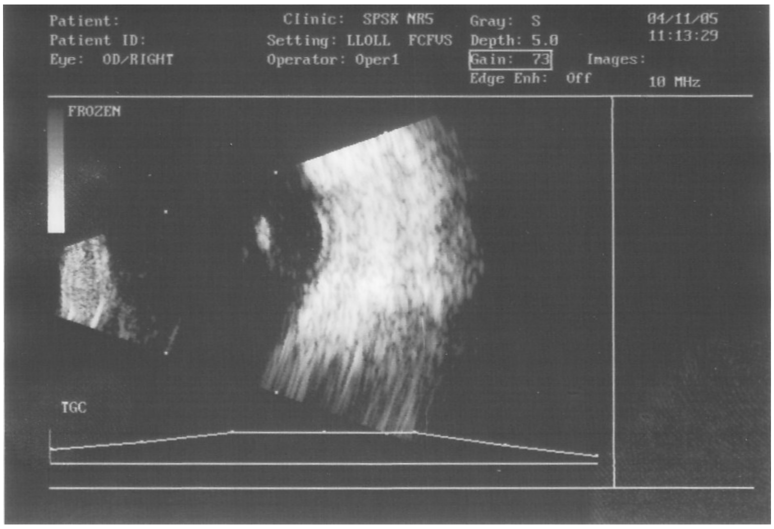

Fig. 8. Posterior subcapsular cataract: an area of high echo in the central part of the posterior lens capsule; low levels of echo around the remainder of the lens [6].

In a standard examination of the posterior segment of the eye, artifacts associated with ultrasound wave reflections from the artificial lens are of the greatest interest.

Eye injuries are a frequent indication that imaging should be used to evaluate the status of the eye because injuries are often associated with a lack of transparency in the anterior chamber (for example, due to blood in the anterior chamber) and the lack of ability to see into the bottom of the eye [7].

Eye injuries may lead to lens subluxation or to complete dislocation of the vitreous chamber. By means of a UBM examination we can confirm the presence of a foreign body within the lens or identify any interruption in the front or rear surface of the lens capsule. This allows confirmation of subluxed lens via an evaluation of the lens ligaments and an assessment of the symmetry of the lens position relative to the surrounding anatomical structures. The limitations of UBM include its inability to visualize a lens dislocated within the vitreous chamber. In this situation it is useful to perform an ultrasound examination of the eye. In some cases, both a foreign body and a lens capsule rupture may be visible on the ultrasound (Fig. 10, Fig. 11). With ultrasound, while it is only possible to perform a partial assessment of the anterior, a full assessment of the posterior chamber of the eye can be completed. The lens dislocated into the vitreous chamber, and the outline of the back of the lens, can both be observed by evaluating the symmetry of its position in order to exclude the subluxation (Fig. 9).

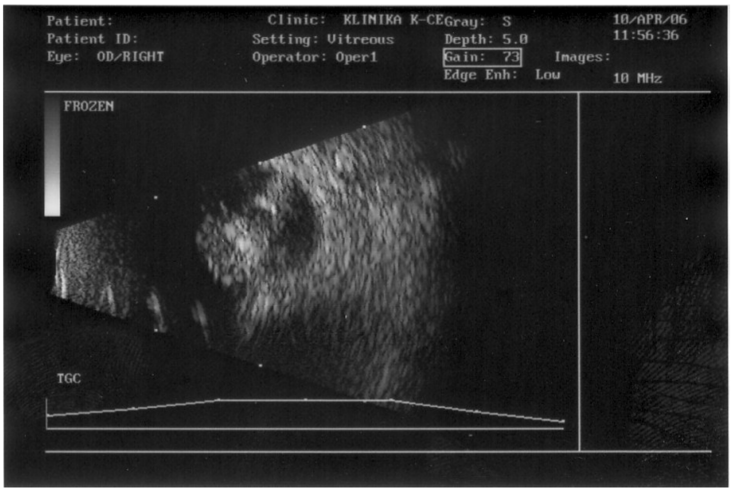

Fig. 9. Subluxed cataract: the lens shift echoes that of the pupil [6].

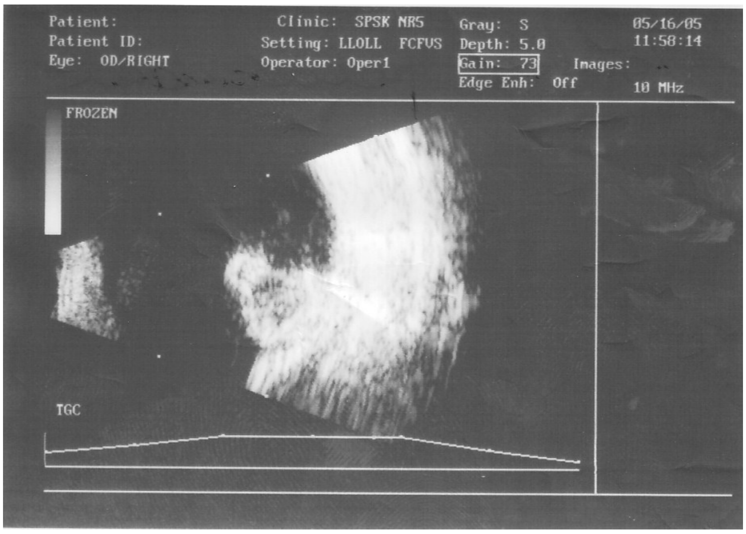

Fig. 10. The irregular echo shape due to damage of the lens capsule. A significant extension of the echo lens [6].

However, for a patient having a suspected perforation of the eyeball, the recommendation is to neither perform tests nor to conduct ultrasound UBM due to possible aggravation of the eye's injury. In such cases, if necessary, the state of the eye should be studied by means of an AS OCT examination. This is an entirely non-invasive and non-contact procedure, and it is easier to implement for serious injuries or when symptoms are painful to the patient. It is also recommended for the evaluation of the anterior segment immediately following surgery. Using this method it is possible to measure and evaluate the cornea, the anterior chamber depth, its width (Fig. 12), the presence of angle glaucoma (Fig. 13), and the lens and iris in general (for example, for cysts or tumors). In any study utilizing OCT, by assessing the anterior chamber depth any intumescent cataract can be diagnosed. In the presence of a mature cataract, by evaluating the corneal-iris angle the risk of facomorfic glaucoma can be determined. A drawback of this technique is the inability to assess the posterior segment of the eye and the absence of any diagnostic approach to the ligaments apparatus or to the sides of the lenses, neither of which are illustrated due to lack of anatomical access. This examination is also impossible to perform on a non-cooperative patient [8, 9, 10, 11, 12].

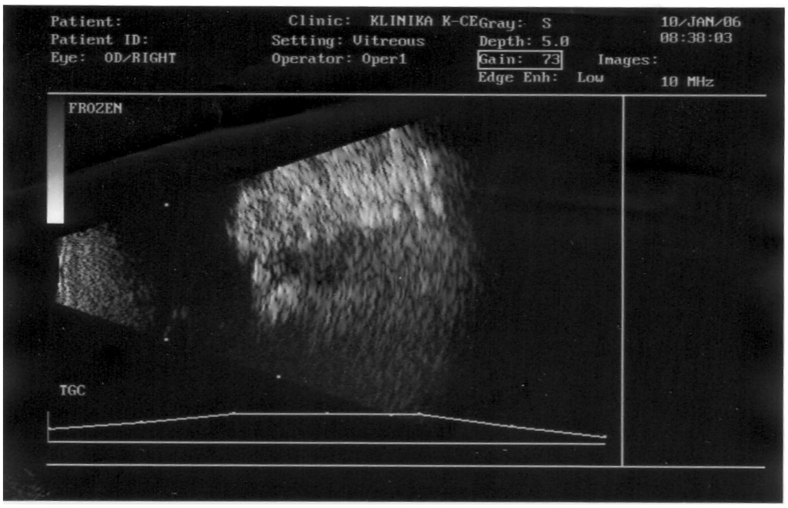

Fig. 11. The increased echo of a foreign body within the lens [9].

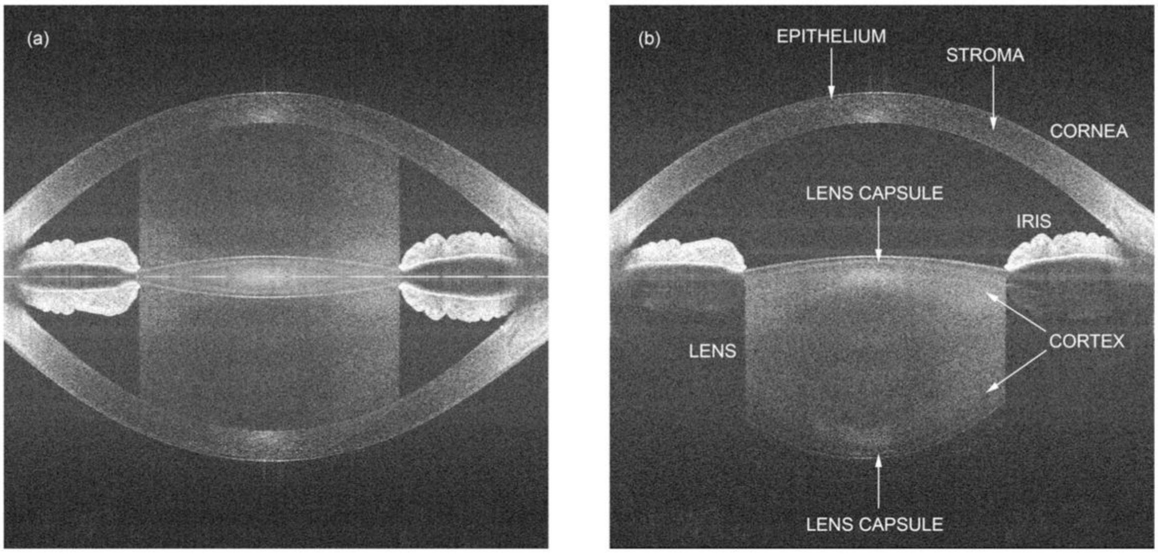

Fig. 12. The measurements of human anterior eye segment conducted in vivo [13].

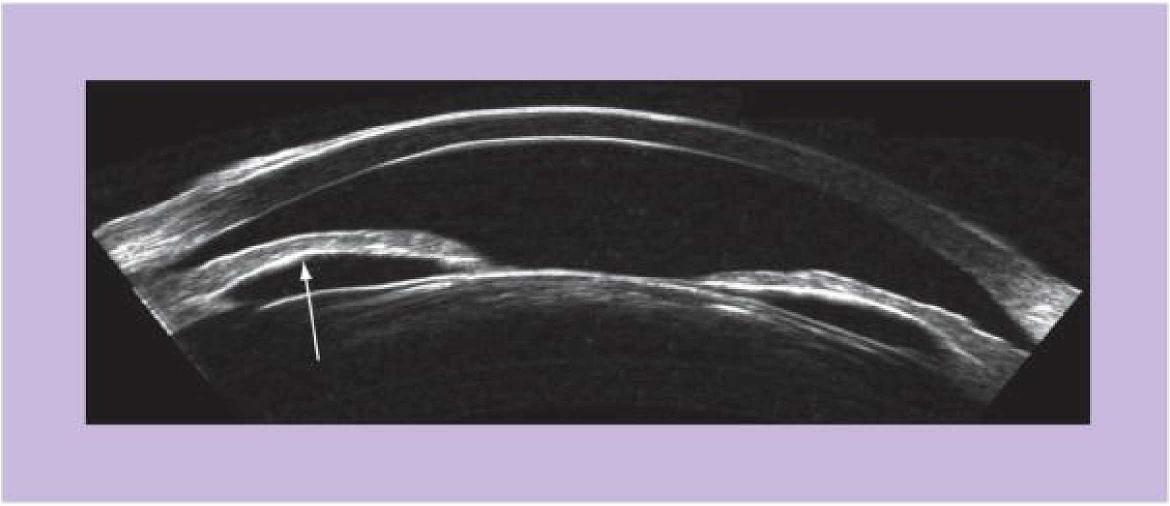

Fig. 13. Moving the iris forward causing closure of the cornea-iris angle [13].

In the course of any inflammation associated with a lens, through ultrasound we can visualize the inflammation's extension into the vitreous material in the form of additional echoes. One example of this would be facolitic uveitis (Fig. 14). In this disorder, lens proteins of ectodermal origin released outside of the lens, for example as the result of a lens capsule rupture causes inflammation. In the ultrasound image, a number of additional echoes are associated with the inflammation's extension into the vitreous.

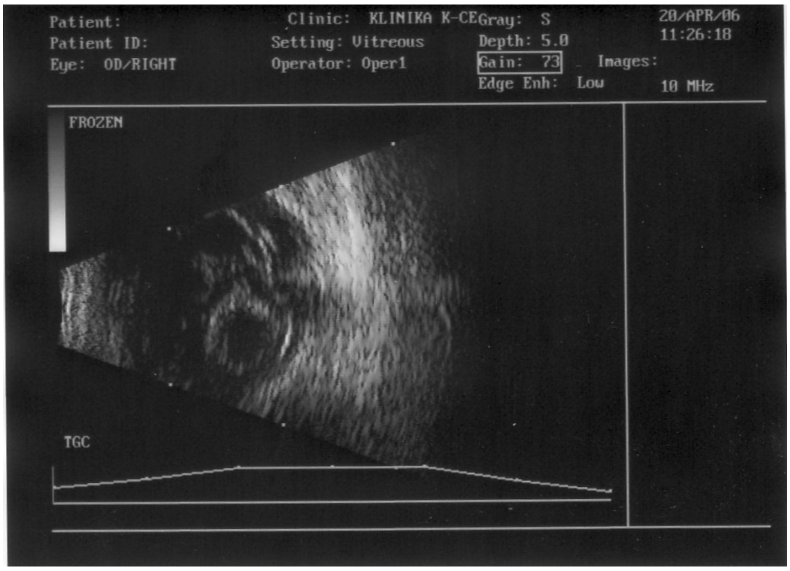

Fig. 14. Inflammatory floaters around the lens-facolitic uveitis [6].

Another example is inflammation of the ciliary body (pars planitis). In the associated ultrasound image a number of additional echoes correspond to the effusion behind the lens (Fig. 15).

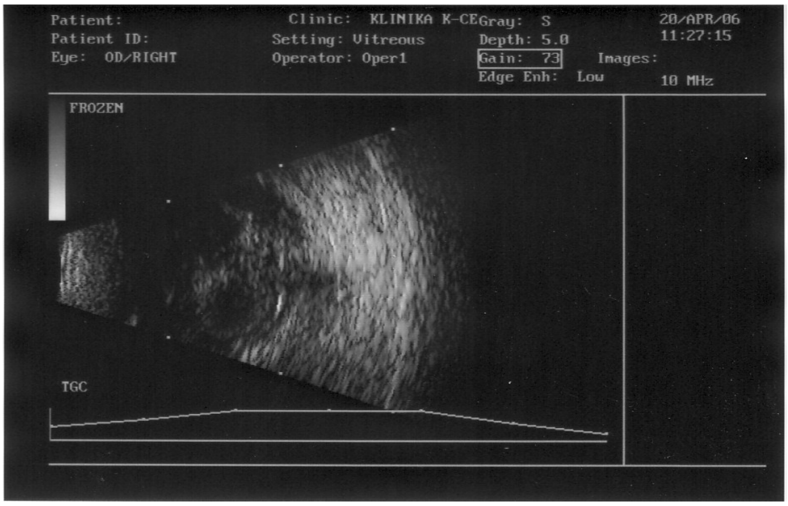

Fig. 15. Inflammatory floaters around the lens: pars planitis [6].

An ultrasound examination also allows for the identification of developmental changes within the eye such as a persistent fetal vasculature syndrome PFVS) (Fig. 16) reaching the lens, or lens subluxation in the case of Marfan syndrome. The existence of developmental changes affects the postoperative prognosis, the course of the recovery and treatment decisions (Fig. 17).

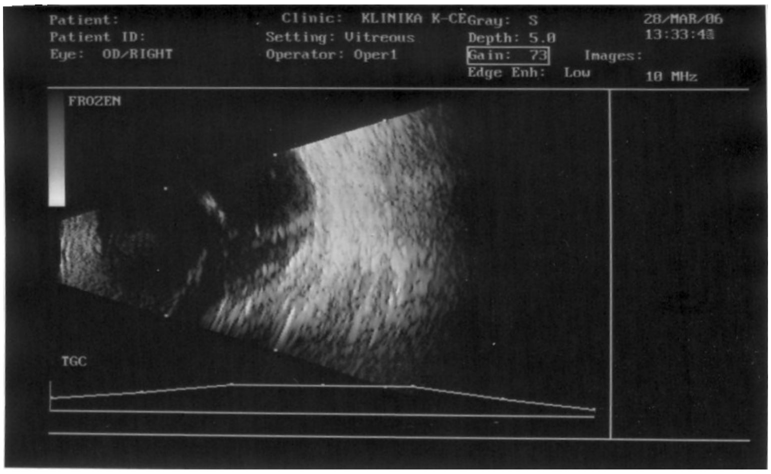

Fig. 16. A persistent vitreous artery reaching the lens [6].

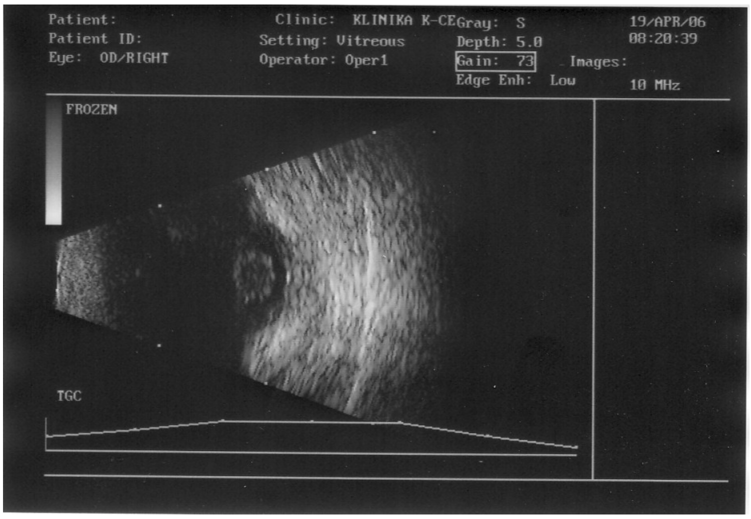

Fig. 17. Congenital cataracts: typical medium to high density echoes corresponding to the location of opacities) [6].

Ultrasound does have intrinsic limitations, including patients with deep eye sockets, lack of cooperation from the patient, situations involving reduced eye movement such as paralysis, orbital tumors and myopathies, and very small eyeballs (< 22mm). The best and most thorough examination of the lens is that provided by ultrabiomicroscopy. While this is not always possible, the clinical pathology of some lenses can be studied by ultrasonography and OCT.

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