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SHORT COMMUNICATION

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Three-dimensional ultrasound findings of the posterior iris region

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Abstract *Purpose:* The aim of this study was to assess the benefit of the three-dimensional ultrasound biomicroscopy in examination of the posterior iris and ciliary body. *Methods:* Three-dimensional visualisation of the anterior eye section was achieved through extension of the existing ultrasound biomicroscope system (Humphrey Instruments). Visualisation of posterior iris and ciliary body pathologies in three patients was performed with a three-dimensional reconstruction technique of B-scans. *Results:* The extended ultrasound system provided three-dimensional visualisation of alterations of the posterior iris region, i.e. iris cysts, ciliary body cysts and solid tumours of the ciliary body and iris. *Conclusions:* The three-dimensional ultrasound biomicroscopy yields extended diagnostic findings regarding iris and ciliary body pathology. This method offers an improved assessment of the posterior surface of the iris and the volume of the ciliary body. Furthermore, these data can be useful for procedures in computer simulation and calculation for a better understanding of the function of the ciliary body in the accommodation process.

Introduction

Ultrasound is the most widely used non-optical diagnostic tool for the imaging of the eye. Pavlin firstly described high-resolution ultrasound biomicroscopy (UBM) in 1990. The authors' results of a series of clinical cases have shown that this method can provide information unavailable with any other imaging technique. Thus, clinical UBM proved to be a tool with a significant potential in diagnoses of ocular diseases [7].

The ultrasound biomicroscope (UBM) provides high resolution and two-dimensional imaging of the anterior segment. It has been used in investigations of anatomic correlations of a variety of disorders, including anterior segment tumours, cysts, plateau iris, malignant glaucoma and pigment dispersion syndrome [1, 2, 5, 8, 9, 10, 11, 12]. The use of high-frequency transducers of ca. 50 MHz enabled high-resolution imaging of the anterior eye segment. This eye segment is a special case where attenuation by intervening tissue can be minimised by application of a fluid-coupling medium between eye and transducer.

Three-dimensional UBM was first described by Coleman et al. [3]. In this study we developed a new method of 3 D UBM and the clinical benefit of this method was demonstrated in a choice of clinical cases.

Patients and methods

Three patients of the University Eye Clinic Rostock were examined with the high-frequency UBM. One patient suffered from contusio bulbi, while the other two had iris tumours. The equipment and technique of the UBM have been described in detail elsewhere [4, 6, 7]. A 50-MHz transducer that achieves a resolution of approximately 50 µm was used. The field of view on screen is limited to 5×5 mm on the commercially available Humphrey unit. Eyecup immersion scanning was performed with a frame rate of 8 Hz.

Scanning was performed under topical anaesthesia with the patient in supine position. An eyecup filled with methylcellulose and

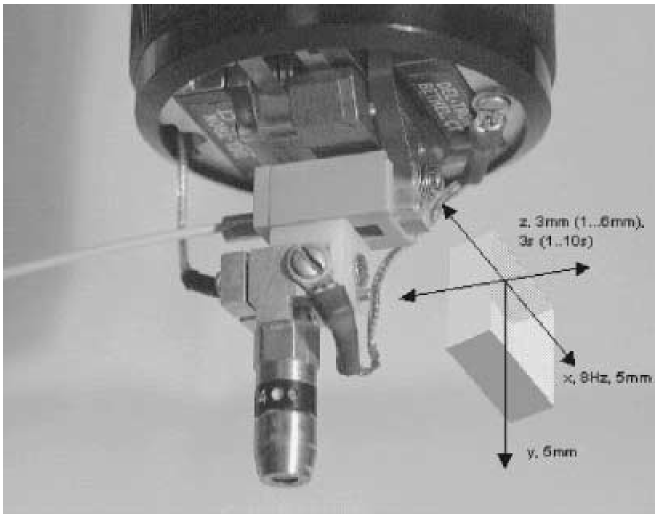


Fig. 1 The extended ultrasound biomicroscopy system – technical arrangement of the US probe

saline solution was inserted between the eyelids. Using a standard B-mode, the transducer was positioned at the centre of the ocular segment concerned. For 3D imaging, the computer-controlled scanning system moved the transducer at 90 deg to the plane of the 8-Hz sector motion (xy-plane) over the eye (z-direction). For this motion, a miniature skid was mounted on the 8-Hz scanning device. The technical arrangement of the US probe is depicted in Fig. 1.

The speed and distance adjustments of the z-motion are variable. The video display of the ultrasound unit was digitised with 8 Hz using a framegrabber board (Hasotec Fg30) synchronised with the motion control system. The acquisition time for a 3D sequence varied between 5 s and10 s; the latter should be the maximum time, considering movement by the patient and the examiner.

The motion control and data acquisition system was connected with a SGI workstation via a local area network for 3D reconstruction using VoxelView (Vital Images, Fairfield, Iowa, USA). This commercial volume-rendering software package provides an interactive environment allowing features such as volume orientation for viewing planes and 3D perspectives, segmentation and determination of distances and surfaces. To process one 3D data set a time of 30 min is necessary. The model-building feature allows the outline of anatomic structures in space and can additionally be used for volume measurements.

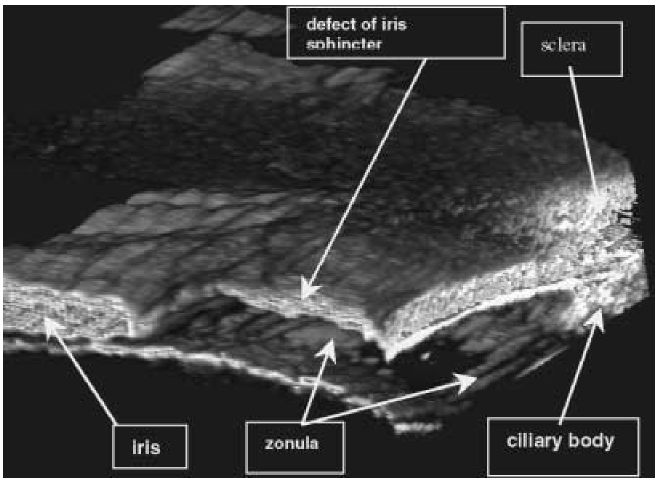


Fig. 2 3D-reconstructed volume of the iris sphincter defect, zonulolysis and prolapse of the vitreous body after contusio bulbi after 3D UBM

Case reports

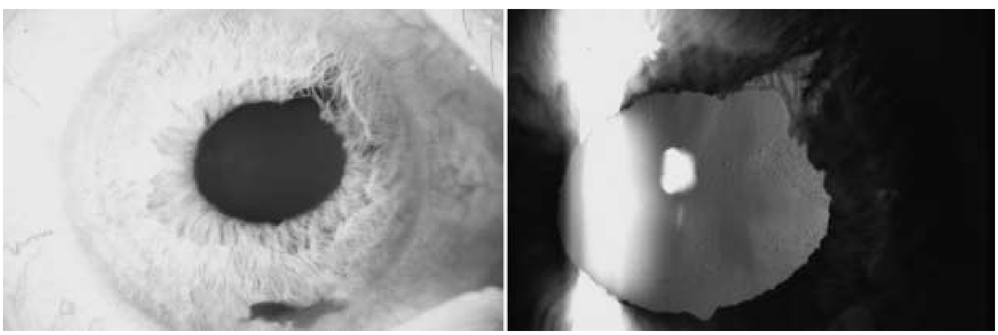
Case 1

A 42-year-old woman with contusio bulbi was referred to the eye hospital. Physical examination revealed fine scratches on the corneal surface and a hyphema 1.5 mm high. Furthermore, a lesion of the iris sphincter and a prolapse of the vitreous body into the anterior chamber of the eye were observed. With the aid of 3D UBM, a sharply marginated defect of the zonules of Zinn leading to the prolapse of the vitreous body could be detected (Fig. 2). We defined these zonules as the structures between the ciliary body and the equator of the lens. Figure 3 shows the clinical situation after the resorption of the hyphema.

Case 2

A 27-year-old woman had a pigmented iris tumour at the base of the iris without contact to the corneal endothelium. 3D UBM was used to demonstrate tumour size and shape. These 3D images are useful in the long-term follow-up to determine increases in tumour volume and extent of tissue involvement. Figure 4 shows the clinical appearance, and Fig. 5 shows the 3D images in two slices in a variety of different planes.

Fig. 3 Clinical pictures of a patient with contusio bulbi and traumatic iris sphincter defect and prolapse of the vitreous body



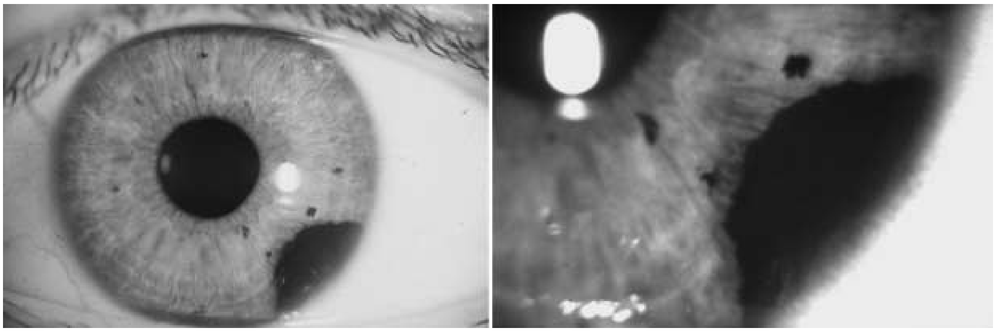


Fig. 4 Clinical pictures of an prominent iris naevus without retrocorneal contact

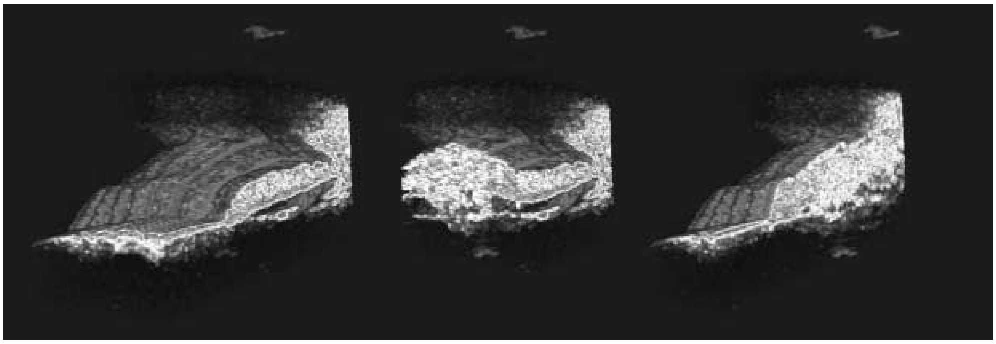


Fig. 5 3D-reconstructed volume of the iris naevus in 3D UBM and two different planes of the digitalised volume

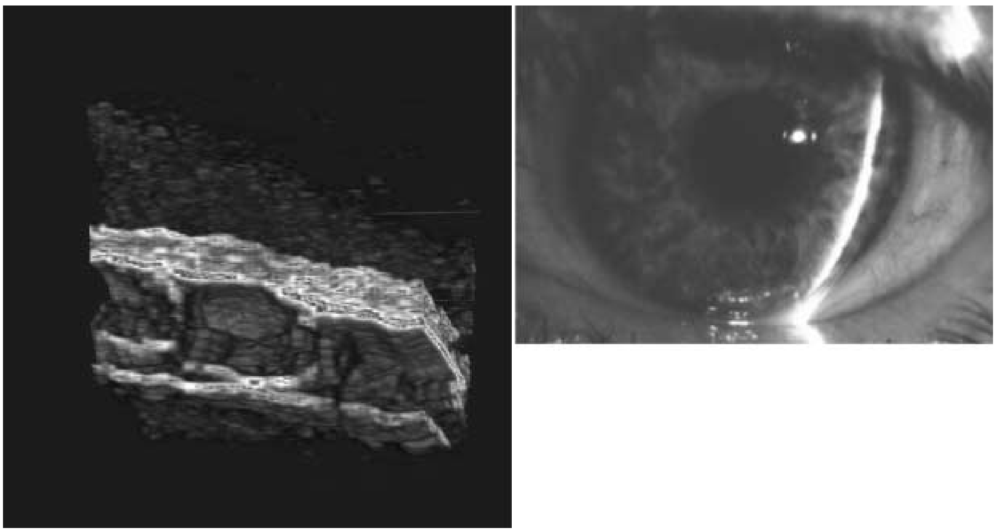


Fig. 6 A view into the volume of cysts of the iris and ciliary body in 3D UBM and the clinical picture

Case 3

A 35-year-old woman had a non-pigmented iris tumour at the base of the iris, in contact with the corneal endothelium. The finding was positive on transillumination. Therefore, the patient was suspected to have iris cysts. Using UBM, one large cyst could be demonstrated in the conspicuous area. Moreover, multiple small cysts were detected in the region of the iris and the ciliary body. Three-dimensional reconstruction, as shown in Fig. 6, revealed a precise visualisation of the cysts and their topographic relations that made it possible to document these findings exactly.

Discussion

This report describes techniques we developed for non-invasive characterisation of tissue microstructures by using high-frequency ultrasound, three-dimensional scanning and image reconstruction.

High-frequency ultrasound provides an axial resolution of approximately 50 μm and a lateral resolution of less than 100 μm in the focal plane. Through the design of a miniature skid we added the ability to acquire multiple and parallel aligned slice images. The 2D sequential, parallel sections were reconstructed into three-dimensional voxel images.

We demonstrated this improved method in three different circumstances: zonulolysis after contusio bulbi, an iris tumour and iris–ciliary body cysts. In all cases, the demonstration with 3D UBM of defects in deeper regions of the eye was successfully performed. Regular monitoring of the bulb tension was recommended in case 1, and repeat 3D UBM every 6 months in case 2 and case 3.

We conclude that 3D UBM of the anterior eye segment provides clinically useful information regarding size, extension and site of the existing pathology. Furthermore, the expanded ultrasound system offers a non-invasive means of obtaining data on the ciliary body region in three dimensions at high resolution. The three-dimensional UBM system is a useful diagnostic tool that also allows volume measurement, distance spacing in volume and two-dimensional images in any plane of 3D volumes. The method improves diagnosis, monitoring and treatment planning. Furthermore, the reported data should be an useful tool for procedures in computer simulation and calculation to achieve a better understanding of the function of the ciliary body in the accommodation process.

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