

# Illuminated artificial orbit for the training of vitreoretinal surgery *in vitro*

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## Abstract

**Purpose** Demonstrations and practical experiments are important constituents of the teaching of surgical principles and techniques to residents in ophthalmology. The objective was to develop an eye-support device for experimental and didactic use during vitreoretinal microsurgery *in vitro*.

**Methods** Various eye-support devices with different light sources and illumination intensities were designed and tested. The main components of the final prototype are a high-intensity halogen lamp, a flexible light guide, a cylinder with a mirror inside, and a replaceable, transparent eye support with a ring-adaptor. Light from the point source is reflected via the light guide into the cylinder and through the eye support transsclerally into the eye.

**Results** The device illuminates the retina and the vitreous body sufficiently. It accentuates the transparent appearance of the retina and makes the three-dimensional structure more visible, for example, in case of retinal detachment. Subretinal tissue can be visualized and differentiated more precisely.

**Conclusions** The device is useful, in the teaching of residents and in experimental vitreoretinal surgery.

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**Keywords:** artificial orbit; eye-support; training; experimental microsurgery; vitreoretinal microsurgery

## Introduction

Teaching and training of microsurgery procedures are main constituents of the medical education of residents in ophthalmology. As mechanical assistance is necessary *in vitro*, various devices for use during the training of different diagnostic or microsurgery procedures

have been reported previously.<sup>1–15</sup> However, there is still a demand for didactic devices teaching experimental handling and controlling of specific problems to novice vitreoretinal surgeons. An optimal device would have the following characteristics: (i) stabilization of the eyeball even during long-term interventions; (ii) prevention of the stretching of the eyeball during scleral depression and tractions; (iii) illumination of the vitreoretinal segment homogeneously without dazzling the operator; and (iv) accentuation of mechanical alterations of the vitreal structures owing to traction movements of the surgeon.

An artificial orbit with diascleral illumination that incorporates the above characteristics has been developed for experimental and didactic use during vitreoretinal interventions *in vitro*.

## Materials and methods

Experiments were performed with various light-sources, including normal incandescent bulbs and halogen lamps, and with different designs of eye supports. The intensity and homogeneity of illumination were compared, as well as the method of eyeball fixation. Devices with differing proportions and dimensions were also tested.

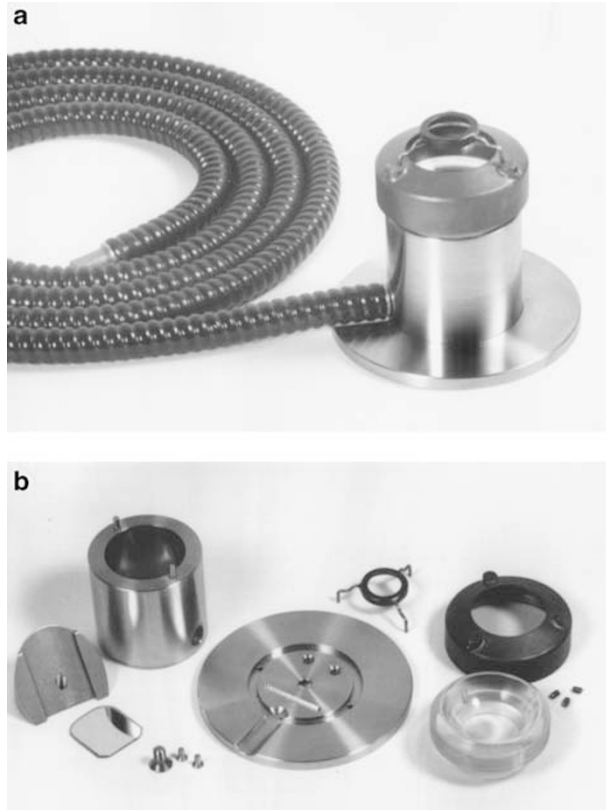
The components of the final prototype (Figure 1a) are as follows: a high-intensity point light source (Zeiss, Germany) using a 100-W halogen lamp (nr. 6834, Philips, Germany), a transformer for supplying the light source (5.4 or 11.5 V output, Spindler & Hoyer, Göttingen, Germany), a flexible light guide (0.5-cm diameter fibre), a cylinder (4.2 cm in height, 3.4 cm in diameter) with a mirror inside (24 mm in diameter, angled 45° relative to the base), and fixed to a plate (6.0 cm in diameter, 1.0 cm in height), and a replaceable eye support with an adapted ring (Figures 1b and 2). The transformer can be used to adjust the light intensity from the point source according to the scleral thickness. The light is fed into the

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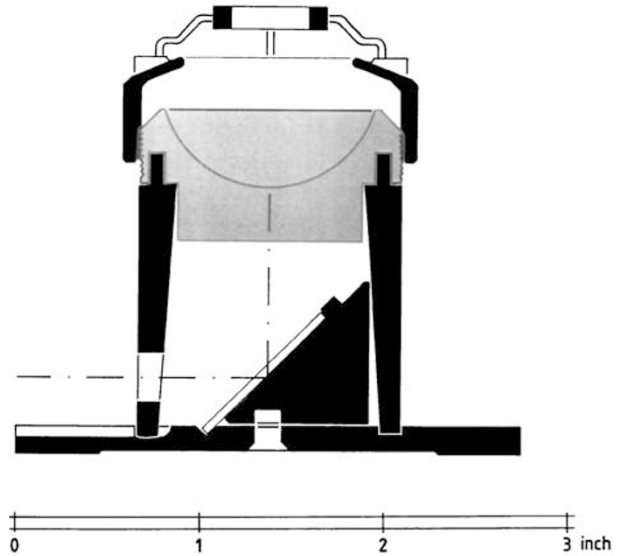


**Figure 1** (a) Artificial orbit with flexible light guide. (b) Principal components of the device.

cylinder using the light guide, and from there via the mirror to the eye support. The eye support is made of transparent polymethylmethacrylate, so that the light penetrates the sclera and illuminates the eyeball. The eye support is fitted simply into the cylinder and is thus replaceable, and it is sandblasted on its underside while its upperside is concave and polished, with dimensions appropriate for the individual eye under investigation. A metal ring is screwed onto the top of the eye support to additionally fixate the eyeball. A further ring for using a Kilp-contact-lens is positioned on top. Each component of the device is fixed to another or to the base unit with screws.

## Results

*In vitro* examinations were carried out with human, rabbit, and porcine eyes obtained the first hours post mortem. The illumination intensity when using incandescent or halogen lamps up to 35 W was not adequate for human or porcine eyes, but 100 W lamps were found to be sufficient. Transformer outputs between 5.4 and 11.5 V were finally chosen for rabbit and porcine eyes, 12 and 96 fL respectively, and human eyes

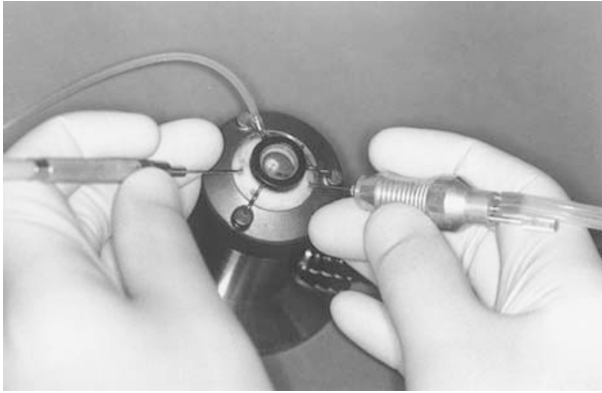


**Figure 2** Sectional drawing of the device.

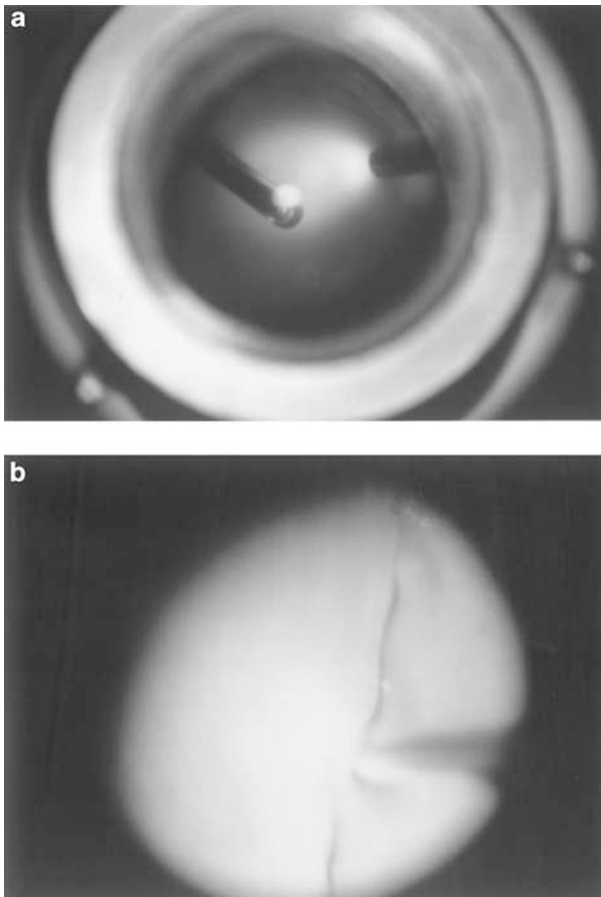
required an intermediate light intensity. Although the device uses a light guide with a small diameter (0.5 mm), the illumination was sufficient for all tested species, most especially for the human and rabbit eyes: scleral transillumination in porcine eyes was sufficient but not very intense even with a brightness of 96 fL owing to the scleral thickness and pigmentation.

The use of different eye supports enables the quasi-simultaneous preparation and investigation of eyes from different species (ie rabbit, porcine, or human eyes in the study). The ring adapter stabilizes the eyeball even during long-term interventions. The eye support prevents the stretching of the eyeball during scleral depression and traction. The diascleral illumination combined with an intraocular light source enables the resident to identify mechanical alterations of the vitreal structure owing to traction movements. The upper ring adapter allows the use of a Kilp-contact-lens without the help of an assistant (Figure 3). The flexible light guide and the inclusion of the mirror inside the cylinder allow the device to be short, resulting in easy and comfortable handling, and illumination of the posterior pole, the vitreous body, and the lens.

As the diascleral light illuminates the retina and the vitreous, it allows the resident to enter the eyeball with the vitreo-cutter without problems usually resulting from the additional handling of an intraocular light source. Illuminating the vitreoretinal space of a porcine eye alone with an intraocular light source results in a whitish appearance obscuring retinal and subretinal details of the fundus (Figure 4a). Without diascleral illumination, retinal vessels and the internal surface of the retina are the only landmarks for the resident (Figure 4b). Instead,

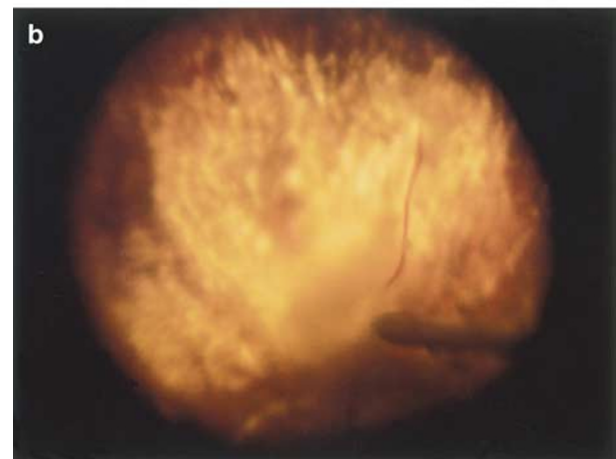
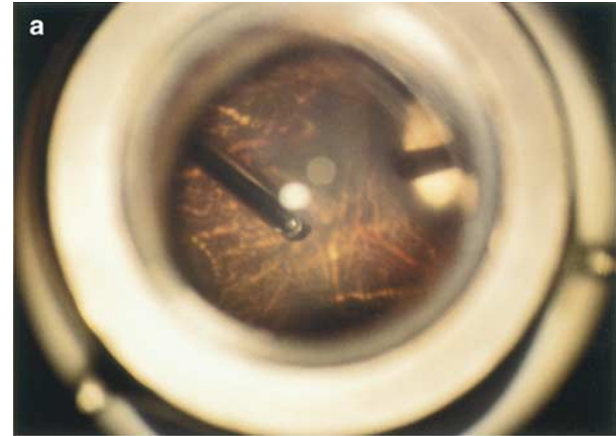


**Figure 3** Artificial orbit with diascleral illumination in use with a porcine eye.



**Figure 4** (a and b) Porcine retina *in vitro* illuminated with an intraocular light source.

the use of the diascleral light enables to see the retinal tissue with its transparent appearance and the underlying uveal vessel architecture. The diascleral illumination accentuates the retina as a three-



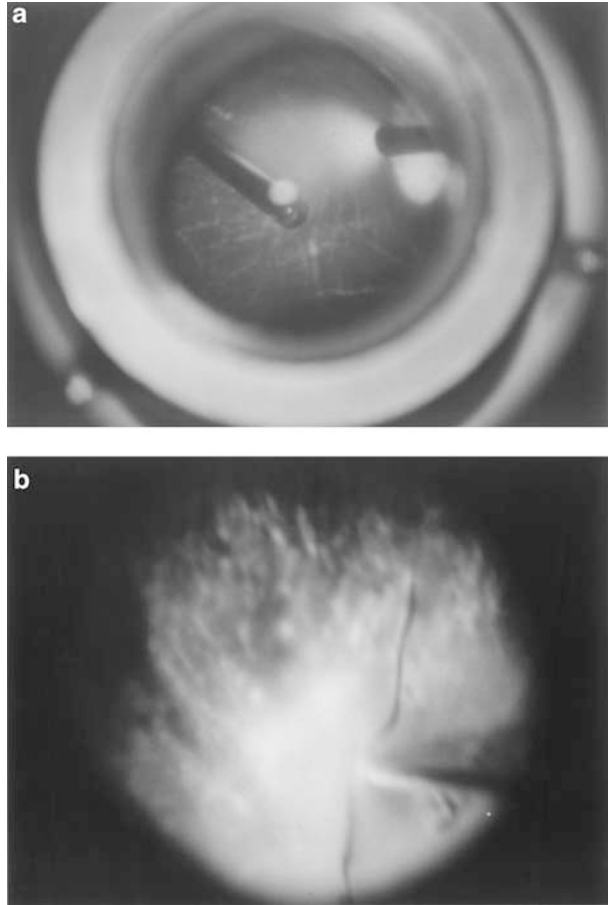
**Figure 5** (a and b) Porcine retina *in vitro* illuminated diasclerally.

dimensional tissue and allows visualization of the subretinal space in case of retinal elevation (Figure 5a and b). As an additional means of an intraocular light source, the diascleral illumination makes retinal defects like holes or detachments easier to be seen (Figure 6a and b).

The diascleral illumination highlights the posterior lens capsule and trains the resident to avoid touching the lens. An axial or coaxial light from a microscope can be used temporarily if the anterior capsule needs to be accentuated.

## Discussion

The demand for didactic methods in ophthalmology has encouraged the development of various instruments for the training of *in vitro* microsurgical procedures and techniques. Devices have been proposed for training in the use of laser application of the anterior and posterior segment<sup>4,6,7,9,10,12</sup> and the use of eye models in indirect



**Figure 6** (a and b) Porcine retina *in vitro* illuminated diasclerally and with an intraocular light source.

ophthalmoscopy.<sup>1,2,8,10,12</sup> Computer techniques, such as those involving the display of images stored on videodiscs,<sup>16</sup> or surgery simulators<sup>13–15</sup> have been of additional use. However, using didactic methods involving artificial eye models or stored images is quite different from experimenting on real tissue. This has led to the developed devices for holding the eyeball for use in the training of *in vitro* microsurgical techniques.<sup>3,5</sup> These devices are especially useful for the training of keratoplasty, glaucoma, and cataract procedures. The eyeholder from Arentsen and Duran<sup>3</sup> can be illuminated, by positioning a light source just under the organ, but *in vitro* studies in our laboratories with comparable incandescent and halogen bulbs up to 35 W did not sufficiently illuminate human or porcine eyes, and the shape and pigmentation of the eyes meant that the illumination was not uniform. We conclude that the device from Arentsen and Dodaro, as well as that from Spitznas,<sup>5</sup> can be used for practising general vitreoretinal techniques, but that they are not suitable for novice vitreoretinal microsurgions because of insufficient

illumination of the subretinal space and the three-dimensional structure of the retina, and they do not allow the quasi-simultaneous study of eyes from different species.

A new artificial orbit consisting of a high-intensity point light source, a transformer, a flexible light guide, and a replaceable eye support for diascleral illumination of eyeballs has been designed and tested. The instrument accentuates the retina and the subretinal space. The method of diascleral illumination is different from that normally used in surgery. However, in comparison to endoillumination or to a light from a microscope, it gives *in vitro* a more natural image. It enables the resident to use the Kilp-contact-lens without further personal assistance. Different-sized eye supports allow the use of eyes from several species. When the additional aim of the Kilp-contact-lens is not necessary, it is also possible to use human eyes, following corneal removal for transplantation, with a specific keratoprosthesis.<sup>11</sup>

The eye support with retrograde illumination also produces good results during microsurgery of the posterior chamber, highlighting the posterior lens capsule during lensectomy, which is a procedure of high risk when performed by novice cataract surgeons.

The artificial orbit is a useful aid in didactic demonstrations and experimental vitreoretinal interventions *in vitro*.

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