CLINICAL TECHNIQUE

Water Gonioscopy: A Technique for Intraoperative Visualization of the Anterior Chamber Angle

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Abstract

Aim and objective: To describe a technique of lens-free gonioscopy that allows the anterior chamber angle to be visualized intraoperatively, without the use of a gonioscopy lens.

Background: Minimally invasive glaucoma surgery (MIGS) is an increasingly popular treatment option for mild to moderate glaucoma. We describe a technique of lens-free gonioscopy that allows visualization of the anterior chamber angle without the use of a lens. This simple intraoperative technique may be used to inspect the placement of MIGS devices within the angle.

Technique: To perform a water gonioscopy, the surgeon sits temporal to the eye. The patient's head is turned 20–45° away from the surgeon, and the operating microscope is tilted 15–30° toward the surgeon. A reservoir of balanced salt solution is allowed to collect in the crater formed by the nose bridge and the bony orbital rim, external to the corneal surface. This body of liquid obliterates the cornea–air interface and hence allows visualization of the anterior chamber. In contrast to gonioscopy using a gonioscopy lens, water gonioscopy offers a lower magnification, ultra-wide field of view for angle visualization.

Conclusion: Water gonioscopy is a useful technique that anterior segment surgeons might use for quick visualization of the anterior chamber angle without the need for additional equipment.

Clinical significance: This is a simple technique that surgeons can use to visualize the anterior chamber angles intraoperatively. It is especially useful for MIGS that are placed within the anterior chamber angle, but this technique may also be used during other anterior segment surgeries, such as visualizing the haptics of an anterior chamber intraocular lens or checking for retained lens fragments in the anterior chamber angles.

Keywords: Anterior chamber angle, Gonioscopy, Minimally invasive glaucoma surgery, Surgical technique, Total internal reflection.

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Background

Minimally invasive glaucoma surgery (MIGS) is an increasingly popular treatment option for mild to moderate glaucoma.[1] Visualization of the anterior chamber angle is required for almost all MIGS surgeries. By convention, a direct gonioscopy lens is used to visualize the angle structures intraoperatively. However, during MIGS surgery, we have discovered a method of inspecting the anterior chamber angle intraoperatively without the use of a gonioscopy lens. The purpose of this article is to describe this technique of direct gonioscopy using a pool of balanced salt solution (BSS) external to the surface of the eye, to negate the total internal reflection that occurs at the cornea–air interface, hence allowing angle structures to be visualized directly.

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Technique

To perform a water gonioscopy, the operating microscope is tilted to 15–30° toward the surgeon. The patient lies supine on the operating table with his head turned 20–45° away from the surgeon, who is seated temporally. A BSS is allowed to pool in the crater formed by the nose bridge and the bony orbital rim, external to the corneal surface. An assistant's thumb may be placed at the inferior-temporal orbital rim as a barrier to the egress of BSS, to encourage the formation of a larger reservoir of water. When the cornea is partially submerged in the body of water, the tear–air interface is obliterated, and the body of water acts in a way similar to a direct gonioscopy lens, allowing the anterior chamber angle to be visualized. Thus, the surgeon has a clear view of the anterior chamber angle without the need for an actual gonioscopy lens. In contrast to gonioscopy using a gonioscopy lens, water gonioscopy offers a lower magnification, ultra-wide field of view. Video 1 demonstrates the visualization of a Hydrus Microstent implant (Ivantis Inc., Irvine, CA, USA) within the anterior chamber angle using a direct gonioscopy lens (top segment of the video) vs water gonioscopy (bottom segment of the video). Figure 1 is a still-frame that shows how the entire length of a Hydrus Microstent implant can be visualized well with the water gonioscopy technique.

Water gonioscopy may be performed during the process of viscoelastic removal (since there is already a natural tendency for some BSS from the irrigation/aspiration probe to pool in the crater formed by the nose bridge and the bony orbital rim when the head is tilted) for an ultra-wide view final visual inspection of the MIGS

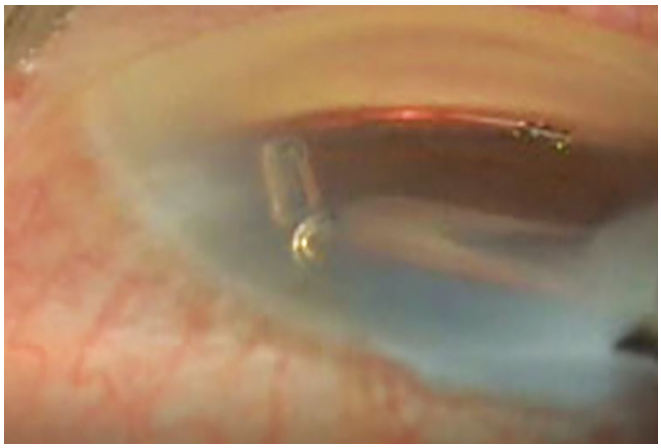

Fig. 1: Hydrus implant visualized through water gonioscopy

device just before the case is closed. Author SP has been performing intraoperative water gonioscopy routinely for his MIGS cases with Schlemm's canal devices during the viscoelastic removal stage of the operation. Additionally, in cases where there is hyphema after MIGS implantation requiring anterior chamber washout with the irrigation/aspiration probe—a step which is usually done without a gonioscopy lens—water gonioscopy allows direct visualization of the angle for further blood reflux while the washout is being performed (Video 2).

Discussion

We have described a technique that allows an intraoperative ultra-wide view of the anterior chamber angle without the use of a gonioscopy lens ("water gonioscopy"). It is a simple and replicable technique that would be useful to many glaucoma surgeons. Although our technique was conceived as an original idea of author SP, a subsequent literature search found that before the invention of gonioscopy lenses, Mizuo had described the phenomenon of being able to view the inferior chamber angle through a pool of water in the lower fornix in 1941.[2] In 1942 and 1957, Kronfeld et al.[3] and Cowen[4] described techniques to visualize parts of the anterior chamber angle through a slit lamp by submerging the cornea in water. With the invention of gonioscopy lenses, this simple concept of lens-free gonioscopy seemed to have fallen into obscurity until 2012, when Shun-Shin published an image demonstrating how the inferior haptic of an anterior chamber intraocular lens could be visualized through a pool of tears/liquid in the inferior fornix.[5] We would like to bring to attention this forgotten technique of lens-free gonioscopy, especially with its application to intraoperative angle visualization following MIGS implantation. We believe that there will be much-renewed interest in this technique as MIGS are being implanted in an increasing number of patients.

Without the use of water gonioscopy, it is impossible to view the anterior chamber angle directly without a gonioscopy lens due to total internal reflection. Total internal reflection occurs for light rays with an incident angle greater than the critical angle when light rays travel from a medium with a higher refractive index to a medium with a lower refractive index. As light from the angle attempts to exit the eye, it strikes the cornea–air interface at an angle shallower than the critical angle, and hence is totally internally reflected back into the eye. With water gonioscopy, a cornea–water interface replaces the cornea–air interface. The refractive indices of the cornea, water, and air are 1.38, 1.33, and 1.00 (respectively).[6,7] Since the refractive index of water is higher than that of air, the critical angle of the cornea–water interface is markedly higher than that of the cornea–air interface (74.5′ vs 48.7′, respectively), as per the following formula:[8]

The critical angle θ_c for a given combination of materials is:

$$\theta_c = \sin^{-1}\left(n_2 / n_1\right) \text{ for } n_1 > n_2$$

Hence, during water gonioscopy, as light from the angle exits the eye, total internal reflection does not occur as the critical angle at the cornea–water interface is large, thus allowing angle structures to be viewed directly without further instrumentation.

The water gonioscopy technique, however, has a few limitations. As a trade-off for an ultra-wide field of view, angle structures are visualized in low magnification. Another limitation of this technique is its restricted use for the nasal angle (when the surgeon sits temporally) and inferior angle (when the surgeon sits superiorly). Visualization of the other angles is limited by the difficulty in maintaining a pool of fluid without the nose bridge and surgeon positioning. However, as MIGS devices are commonly inserted in the nasal quadrant,[9] water gonioscopy may be useful in many situations.

Surgeons may potentially utilize this easy technique for angle visualization following the implantation of other Schlemm's canal devices (e.g., iStent, Glaukos Corp., Laguna Hills, CA, USA) and emerging goniotomy/trabeculotomy techniques. Water gonioscopy may also be used to inspect the haptics of anterior chamber intraocular lenses or to check for remnant lens fragments trapped in the angles during cataract surgery, particularly in femtosecond laser-assisted cases as lens fragments may be small.

Conclusion

Water gonioscopy is an interesting technique that anterior segment surgeons might use for quick visualization of the anterior chamber angle without the need for additional equipment. In contrast to gonioscopy with a gonioscopy lens, water gonioscopy offers a lower magnification, ultra-wide field of view of the angle structures. Potential uses of water gonioscopy include inspection of MIGS devices within the anterior chamber angle, visualizing the haptics of anterior chamber intraocular lenses, and screening for remnant lens fragments trapped in the angles during cataracts surgery.

Clinical Significance

Water gonioscopy is a simple intraoperative method of viewing the anterior chamber angle without the use of a gonioscopy lens. In contrast to gonioscopy using a gonioscopy lens, water gonioscopy offers a lower magnification, ultra-wide field of view of the angle structures.

Video 1: The view of the Schlemm canal implant is visualized through a direct gonioscopy lens (top). The view of the implant in the similar eye through water gonioscopy (below)

Video 2: Hydrus implant visualized through water gonioscopy. The surgeon can visualize the source of bleeding while removing the viscoelastic soon after implantation of the Schlemm canal implant

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