

Novel and semi-Automated 360° Gonioscopic Anterior Chamber Angle Imaging in under 60 Seconds

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Background

- In the US, only 45.9% of new patients being evaluated for glaucoma had gonioscopy performed during their initial evaluation. ¹
- Gonioscopy only performed in 49% patients within 4 to 5 years prior to glaucoma surgery ²
- Main challenges: document gonioscopic findings in a reproducible and expeditious manner in the clinical setting. ^{3,4}
 - Time-consuming
 - Requires expertise in managing the 3-mirror gonioscopy lens, as well as, using a high-resolution camera system.
 - Images are typically limited to 4 quadrants and resolution (focus) can be variable depending on operator abilities.
 - Variability introduced by different lighting conditions between patients and between visits which makes it difficult to evaluate patients over time.

Background

- A novel gonioscopy imaging system has recently been introduced to provide high quality anterior chamber angle (ACA) images and at the same time overcome limitations from the aforementioned challenges.
- The NGS-1 automated gonioscope (NIDEK Co., Gamagori, Japan) is able to easily capture circumferential 360-degree gonioscopic images of the anterior chamber angle in less than 60 seconds per eye.



Side view of NGS-1



Patient's view of NGS-1

Purpose

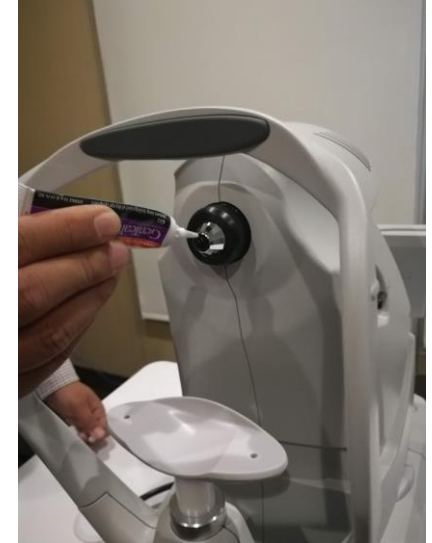
To study the ability of the novel imaging system to quickly and easily document the full 360-degree of the anterior chamber angle in a standardized manner

Methods

- Design: Cross-sectional cohort study
- Participants: Eighty-four eyes from 50 subjects were included in this study including 26 eyes from 17 normal participants, and 58 eyes from 33 consecutive adult patients from the glaucoma clinic at UCLA Doheny Eye Centers

Methods

- The newly-introduced, commercially available Gonioscope (GS-1, Nidek Inc., Japan) was utilized to perform semi-automated imaging of the full 360-degree iridocorneal angle on participants under an IRB-approved study
- Topical proparacaine was administered to the eye to anesthetize the eye and imaging was completed using the 16-mirror, machine-attached-gonioscopic prism lens coupled with lubricating ophthalmic gel ointment



Left: The 16-quadrant machine-attached-gonioscopic prism lens + camera system which will make contact with patient's eye. Each facet of the prism lens covers 22.5-degree portion of the anterior chamber angle.

Right: The operator is applying gel onto lens before the patient's eye can be engaged to the lens/camera.

Methods

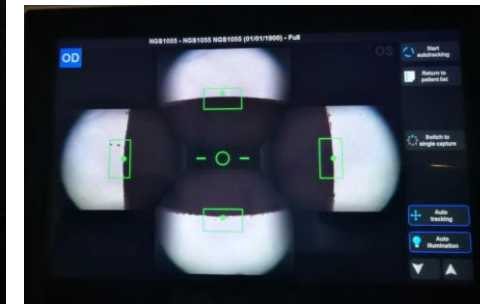
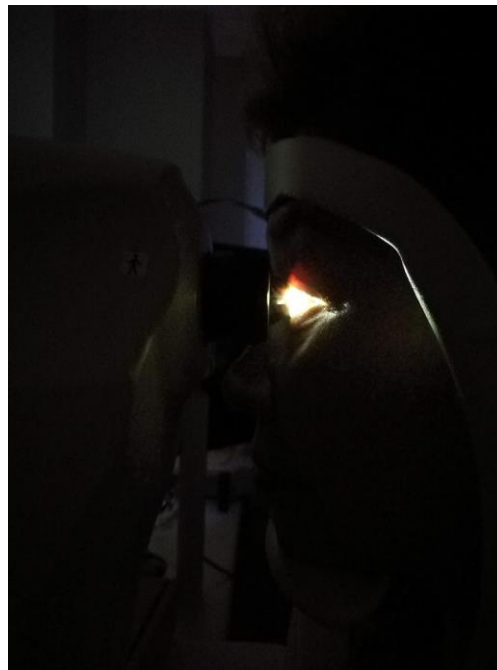
The 1st of the 2-step image acquisition process is analogous to manual gonioscopy, while the 2nd step is performed by the instrument in an automated fashion.

1st Step: the instrument is manually moved forward by the operator to allow the machine-attached-lens to make contact with the patient's corneal surface and achieve coarse focus (time=30 seconds)

Figure Left: The operator is using the camera lens to engage patient's cornea in a dark imaging environment using only light from instrument

Figure Right top: the operator is in the process of manually achieving coarse focus

Figure Right bottom: Coarse focus is achieved when the "boxes" become green in all 4 quadrants

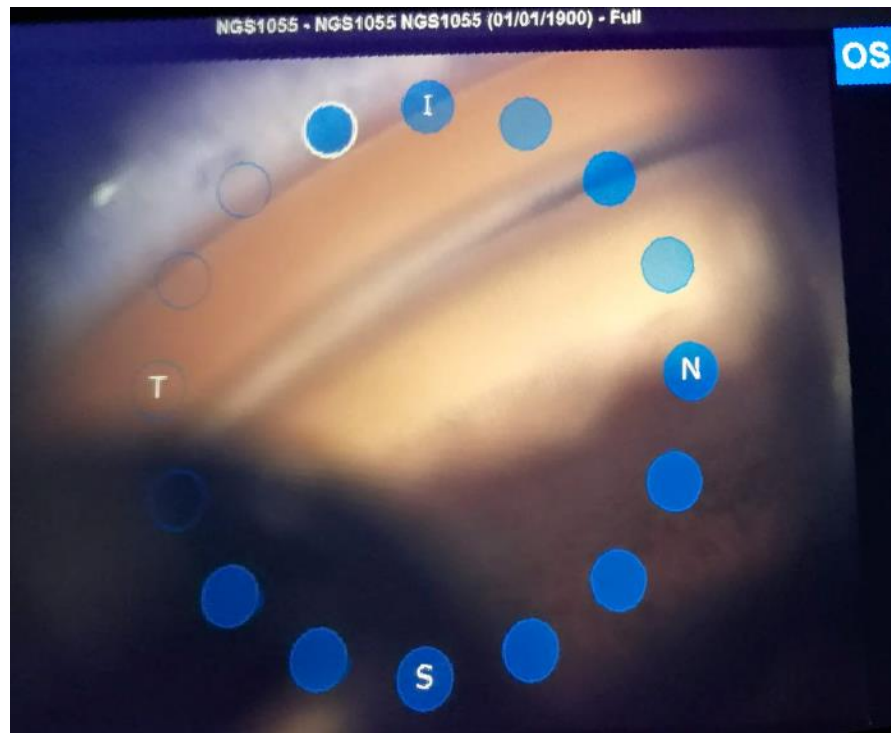


Methods

The 1st of the 2-step image acquisition process is analogous to manual gonioscopy, while the 2nd step is performed by the instrument in an automated fashion.

2nd Step: the instrument automatically achieves fine-focus on the iridocorneal angle and takes 16 sequential high-resolution photos at multiple different focal planes (time=less than 30 seconds).

Figure on Right: The automatic 2nd stage of imaging; the device is automatically taken angle photos in 12 out of 16 quadrants (filled blue circles) with 17 levels of fine focus each and will complete the other 4 quadrants next (empty blue circles)



Methods

An image quality review of the automated gonio-images was performed by two Doheny Image Reading Center certified-graders who worked together and selected the best quality and best focused gonio-images (with clear and visible details) out of the 17 gonio-photographs for each of the 16 portions of the angle.

Figure: The instrument will chose the BEST image of the 17 (with varying depth-of-focus) from each of the 16 quadrants, but the Operator (Grader) can manually supersede and SELECT another BEST image. The instrument typically does select the most focused image, but manual control is useful in selecting an image when there is a device or implant in the angle which may be better-focused on an alternate image than the one selected by the instrument.



The horizontal thumbnails at the bottom of the screen mark the quadrant under examination. The thumbnails on the right column mark the images of various fine focus level in the specific quadrant. The one in blue box with a yellow star mark the chosen image to represent this quadrant.

Results

- Main Outcome Measures: Successful qualitative imaging of anterior chamber iridocorneal angle in normal and glaucomatous eyes including visualization of various implanted devices within angle before and after surgery in less than one minute per eye
- In this pilot study, the full 360-degrees of iridocorneal angles of 84 eyes from 50 subjects normal or with glaucoma were successfully imaged using Nidek GS-1 in under 60 seconds
- All eyes were able to be imaged in one sitting, and we were able to image the full spectrum of angles from narrow/closed to fully open

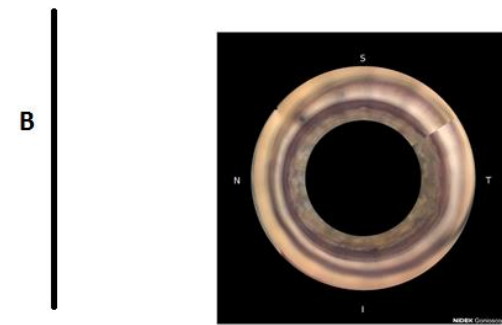
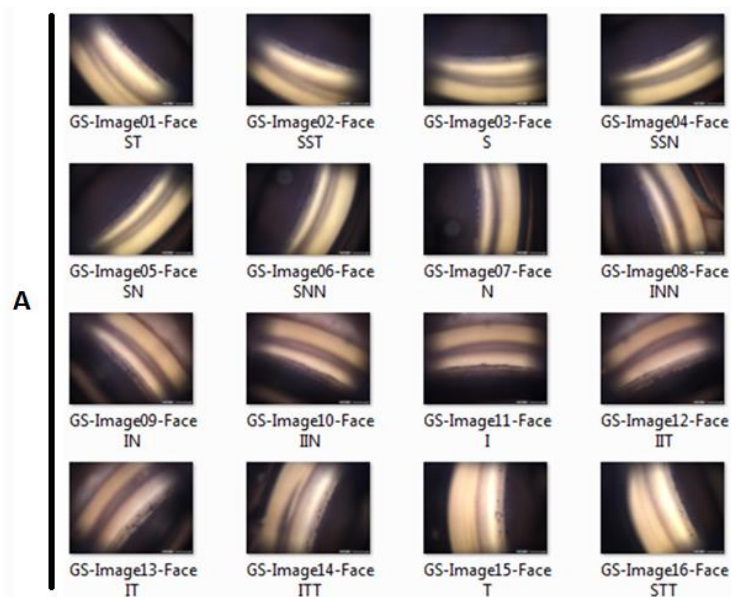
Results

The 360-degree view of the images were able to be displayed in 3 available formats:

(A) 16-quadrant display

(B) Circular display, which is “stitched” images displayed in a view as typically “seen” by physician during gonioscopy

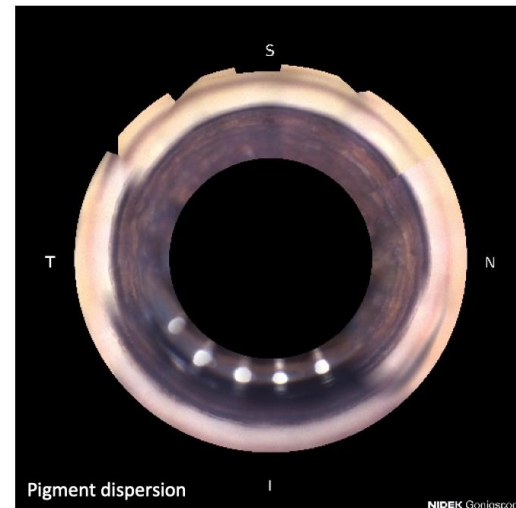
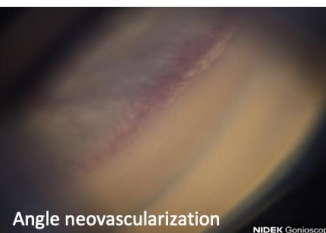
(C) Linear display, which is an “unrolled” image allowing easier side-by-side comparison of various quadrants



Results

Successful imaging was also achieved of surgical devices and post-surgical conditions including:

- CyPass
- iStent
- XEN
- Baerveldt tube shunt
- Angle recession with iridodialysis
- Angle neovascularization
- Pigment dispersion
- Post-trabeculectomy sclerostomy
- Post-peripheral iridotomy



Conclusion

- In both normal and glaucoma eyes, the newly introduced, semi-automated imaging system allows the ability to easily evaluate post-angle surgery changes and assess position of implanted devices in the anterior chamber angle
- This device allows regular testing and longitudinal evaluation by providing these advantages:
 - Requires minimum training to operate
 - Imaging procedure is fast – in less than one minute – allowing use in busy clinic
 - Document the full 360-degree iridocorneal angle views
 - Images recorded in high resolution with varying depth-of-focus
 - Images taken in standard lighting conditions