

# Simultaneous Stereo Retinal Imaging in Glaucoma: Color 35-mm Film vs 6.1 Megapixel Digital Imaging

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## PURPOSE

**Purpose:** To validate a digital simultaneous stereo photography system by comparing it to conventional 35-mm silver halide – based film for the evaluation of morphologic optic disc features in patients with glaucoma.

## METHODS

**Methods:** Fifteen digital simultaneous stereo photographs (SSPs) and 15 corresponding film-based SSPs of glaucomatous optic discs were graded by 2 glaucoma specialists. The vertical and horizontal cup-to-disc ratio was measured for each optic disc image and each was assigned a quality score (1=worst, 5=best). The 2 expert graders were asked to randomly evaluate digital and film-based SSPs twice, for a total of 60 evaluations each (30 for digital and 30 for film-based). A Nidek 3-Dx simultaneous stereo disc camera (Gamagori, Japan) was used to capture images of the optic nerve, first with standard 35 mm film, then with a 6.1 megapixel camera attachment for digital images. Digital SSPs were evaluated directly on a computer monitor (32 bytes with a resolution of 1024 x 768 pixels) using a Berezin Stereo Viewer (Irvine, California; [www.berezin.com/3d/](http://www.berezin.com/3d/)), held at a fixed angle to the monitor (Fig.1). Film-based SSPs were evaluated using a Pentax stereo slide viewer (Tokyo, Japan). Images were placed directly on a light box over a neutral density filter to match the luminance between the computer screen and the light box (Fig.2).



**Fig. 1**  
Digital SSPs were evaluated directly on a computer monitor (32 bytes with a resolution of 1024 x 768 pixels) using a Berezin Stereo Viewer (Irvine, California; [www.berezin.com/3d/](http://www.berezin.com/3d/)), held at a fixed angle to the monitor.



**Fig. 2**  
Film-based SSPs were evaluated using a Pentax stereo slide viewer (Tokyo, Japan). Images were placed directly on a light box over a neutral density filter to match the luminance between the computer screen and the light box.

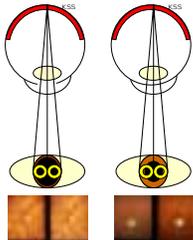


Fig 3a

Fig 3b

**Fig. 3a b**

The Nidek 3Dx stereo camera captures both **left and right** retinal images simultaneously through a sufficiently dilated pupil.

When the pupil is not sufficiently dilated, an artifact will appear as a dark or black field in one of the 2 channels, as seen in Fig 3b. Uneven focusing between the 2 channels may result when one channel passes through the center of the physiological lens of the patient while the other channel traverses a thinner area of the same lens (less dioptric power resulting in uneven focusing).

## DISCUSSION

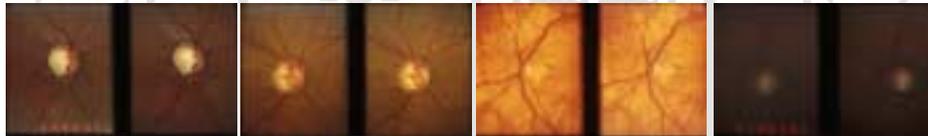
Parameter standardization is essential when comparing digital and film-based SSPs. We controlled as many parameters as possible, including luminance, image viewing distance, and angle of view from the observer to the monitor and light box. Failure to standardize these parameters may bias results (4). The American Telemedicine Association has issued recommendations regarding equipment specifications as well as image acquisition and analysis. Standardization will become increasingly important to compare results from multicenter studies in which different digital imaging systems are used. Processing and development of film-based SSPs requires around 3 days. Moreover, there is no guarantee that both left and right channels will be exposed at the time of image capture.

### Digital photography has several advantages:

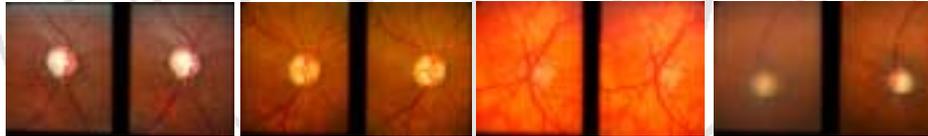
- Decreased light requirement compared to film photography, ensuring greater patient comfort
- Instant feedback on the quality of images
- Proper exposure of right and left channels at the time of image capture
- Storage of images as part of electronic medical records
- Transmittal of images to a reading center for multicenter clinical trials, an essential element in telemedicine

Our digital SSP system includes the Nikon 6.1 megapixel digital camera, which offers the required image resolution, together with a computer monitor of compatible resolution for image viewing. A DICOM capture protocol was adopted for all image capture and transfers following ATA's recommendations (5).

**Fig. 4a**  
35-mm silver halide film, Kodak 100 ISO Ektachrome E-6 Film



**Fig. 4b**  
Digital Images Captured With a Nikon 6 Mp Digital Camera



**Table 1:** Vertical and Horizontal Cup-to-Disc Ratio in Digital and Film-based Stereo Photography

	Film C/D V	Digital C/D V	Film C/D H	Digital C/D H	Film Score	Digital Score
Rater A	0.68	0.66	0.58	0.57	3.80	3.73
Rater B	0.65	0.65	0.63	0.62	4.33	4.07
Overall	0.66	0.66	0.61	0.59	4.07	3.90

Legend: C/D, cup-to-disc ratio; V, vertical; H, horizontal.

**Table 2:** Comparison of Digital and Film-based Stereo Photography

Outcome	Mean Difference	% Difference RMSE	Spearman Correlation	Grader Bias p value
Quality Score (1-5)	0.17	17.4	0.69	0.23 (NS)
C/D V	0.012	7.5	0.98	0.26 (NS)
C/D H	0.01	11.1	0.95	0.98 (NS)

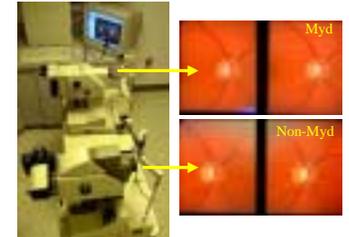
Legend: Root Mean Squared Error (RMSE) – Not Significant (NS): grader by paired t test

## CONCLUSIONS

The advantage of stereo fundus photography of the optic disc over sketches or descriptive explanations of morphologic features has long been recognized and the technique is now routine in clinical practice (1). Fundus stereo photography permits clinical examination of pathophysiologic features of glaucoma beyond the 2-dimensional view offered by conventional photography. Simultaneous stereo cameras provide images with a constant stereo base separation. This ensures greater accuracy for both subjective and quantitative analyses since stereo images are exposed at the *same* magnification and have the *same* stereo base separation at a particular moment in time (2,3).

Digital photography has several advantages including instant feedback on image quality—to verify evenness of exposure, correct focus, artifacts due to blinking of the eye—electronic storage, and applicability to telemedicine. In this study, the quality of digital images of glaucomatous optic discs correlated well with that of film-based SSPs. The mean difference between digital and film photography near 0 for the 3 outcomes that we evaluated, namely, C/D V, C/D H, and quality score. Moreover, no significant grader bias was observed for any of the outcomes.

This study indicates that digital SSPs correlates well with film-based SSPs for the assessment of optic nerve head features in glaucoma. Recently, we have obtained nonmydriatic digital SSPs (Fig 5). Omitting pupil dilation enhances patient comfort, which increases the effectiveness of the technique. Validation of digital nonmydriatic SSPs will be necessary to assess the technique's usefulness as a clinical screening tool.



**Fig. 5**  
Top image is captured with conventional mydriatic unit while bottom image is of same patient captured with a non-mydriatic camera.

## References:

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