Basic Developing Techniques for Fluorescein Angiography

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Introduction

One way to define photography is as a process of information transferral. As ophthalmic photographers, we are responsible for the transferral of information concerning our patient's eye onto film. As fluorescein angiographers, we must transfer specific information documenting the pathways of fluorescein dye as it travels through the patient's retinal blood vessels. Through the manipulation of film processing techniques, we can enhance or suppress that information.

Developing Your Own Film

Developing and printing the results of fluorescein angiography are not difficult. The technique is basically identical to that used by millions of amateur photographers in basement and bathroom darkrooms. However, many professional angiographers choose not to do it themselves.

There are at least three good reasons retinal angiographers should be involved in darkroom procedures—control, feedback, and cost. In developing and printing the results of fluorescein angiography we can enhance or suppress information. If the photographer has no input into how the film is processed, he cannot choose the information to be enhanced. How can he know certain information is not being suppressed? How can he be certain his photographic technique is yielding the best results? Doing your own, or having close control over darkroom procedures ensures the ability to keep the quality of your angiography high.

Health care costs have risen sharply, almost exponentially in the last twenty to thirty years. As health care professionals, we should seek ways of lowering costs of our services to the community. Instituting in-house processing of angiograms is a good place to begin. A recent conversation with a certified retinal angiographer revealed that his hospital was paying $15.75 for the development and printing of each fluorescein angiogram. When he investigated an in-house darkroom, he found his cost to be $3.00 per angiogram, discluding an initial investment in equipment, which will last ten to twenty years.2 In-house processing of fluorescein angiograms is very cost effective.

Processing—An Overview

When light strikes unexposed film, it causes a change in the sensitized emulsion, creating a latent image. This image is both fragile and transient. It is composed of silver bromide particles whose chemical character has been slightly changed.

In processing film, we stabilize the latent image. First, we introduce the film to a developer. The developer latches onto and dissolves the bromide portion of the exposed silver bromide. Development is ended, at the proper predetermined time, by switching to an acid stop bath. Now the emulsion contains metallic silver (the latent image) and unexposed silver halide (still light sensitive). Transferring the film to the fixer dissolves the unexposed silver halide, allowing the now stable silver metal in the film to be exposed to light without any changes. [5] The next processing step involves washing the fix out of the emulsion. The acidic nature of the fixer decomposes the gelatin and film base, if left for an extended period of time. If not fully washed out, fixer can cause staining of the negative. Dust free drying completes the process.

Specific, step by step instructions with illustrations can be found in two general photography references: *The Craft of Photography,* by David Vestal © 1975, and *Photography—Art and Technique,* by Alfred Blaker, 0 1980.

Controlling Development

Exercising control over this process is a matter of standardization of procedures and selection of developers. Both stop bath and fixer have little effect on the final image, as long as the recommendations of the manufacturer are followed.

Standardization of procedures is a basic prerequisite to consistent results. When experimenting with or making changes in your processing, be sure to change only one factor at a time. This allows you to pinpoint problems, and easily diagnose them.

The development of film is a chemical reaction— and subject to conditions which can intensify or reduce its speed. Some developers are more active (act more quickly) than others. The same developing agent can be made to act differently by varying the dilution, temperature, and time.

Developing agents can be classified according to three general characteristics: *contrast, film speed,* and *graininess.1*

Contrast is the ratio between dark and light tonalities in a photograph. A well processed negative has dense and clear

DEVELOPER/TIME COMBINATIONS SUGGESTED BY WONG, GEORGE, AND ZEISS

Power Generator	Filters (Exciter/Barrier)	Kodak Film	Flash Setting	Developer	Development Time/Temperature
Topcon TRC-F	BA-15*	Tri-X	100 watt-seconds	**Kodak D-11**	**7 mins 70F**
Topcon TRC-F	E4-B5+	Tri-X	100 watt-seconds	**Kodak D-11**	**6 mins 70F**
Topcon TRC-F3	BA-15*	Tri-X	100 watt-seconds	**Kodak D-11**	**8-1/2 mins 68F**
Topcon TRC-F	E40-B50+	Tri-X	100 watt-seconds	**Kodak D-11,1:1**	**8 mins 70F**
Zeiss Siemens	E4-B5+	Plus-X	3	**Kodak D-11**	**7 mins 68F**
Zeiss Dyonics	E4-B5+	Tri-X	200 watt-seconds	**Kodak I-IC-110,1:7**	**10 mins 70F**
Zeiss Dyonics	E40-B50+	Tri-X	200 watt-seconds	**Kodak HC-110,1:7**	**6 mins 70F**
Zeiss FF II	E4-B5+	Tri-X	High	**Kodak D-11**	**6 mins 72F**
Zeiss FF II	KW47A-W15++	Tri-X	Medium	**Acufine**	**8-1/2 mins 68F**
Zeiss PP 260	E4-B5+	Plus-X	3	**Kodak D-11**	**7 mins 68F**
Zeiss FF III	E4-B5+	Tri-X	2	**Kodak D-11**	**7 mins 72F**
Zeiss FF III	E40-B50+	Tri-X	2	**Kodak D-11**	**5 mins 72F**
Zeiss FF III	E40-B50+	Tri-X	4	**Kodak D-11,1:1**	**8 mins 70F**
Kowa RC-W	E40-B50+	Tri-X	300 watt-seconds	**Kodak D-11,1:1**	**8 mins 70F**
Kowa RC-2	E40-B50+	Tri-X	6	**Kodak D-11**	**12 mins 70F**
Nikon Retinapan 45-II	E40-B50+	Tri-X	5	**Kodak D-11,1:1**	**8 mins 70F**
Zeiss FF III	SB4-SB5	Tri-X	2	**Kodak D-76,1:1**	**10 mins 68F**
Zeiss FF III	SB4-SB5	Tri-X	2	**Acufine**	**10 mins 68F**
Zeiss FF III	SB4-SB5	Tri-X	2	**Kodak D-76**	**7 mins 68F**

Match interference filters by Topcon Corporation of America, Paramus, NJ
Interference filters by Spectrotech Company, Lincoln, MA
++ Kodak Wratten filters by Eastman Kodak Company, Rochester, NY

areas, as well as areas of intermediate densities (greys). Negatives with too much contrast (hard negatives) have only dense silver areas and clear non-silver areas—no in between greys to convey subtle information. Negatives with too little contrast (muddy negatives) have only intermediate greys and are difficult to interpret.

All film comes with a pre-rated film speed from the factory. For example, Kodak Tri-X has an ISO rating of 400. This film speed is appropriate when developing according to the manufacturer's specifications. If we overdevelop ("push") the film by increasing the activity of the developer through an increase in time, concentration or temperature, we increase the *effective film speed.* Tri-X can have an effective film speed of 800, 1600, or even 3200 when push processed. The more active the developer, the higher the effective film speed. When a high-speed film (Tri-X ISO 400) is used with an active developer (Kodak D11 or D19), especially when overprocessed, information from low light situations (e.g., fluorescein angiography) can be maximized.

Graininess is a subjective term used to describe an estimate of the size of silver clumps making up the image. Granularity is the objective measurement of the same, and is based on microdensitometric trace measurements.[4] Grainy images use larger clumps of silver to form the image. Fine detail is dependent on a fine grain image. Increasing the graininess by increasing film speed or overdeveloping suppresses the fine detail of microvascular information in fluorescein angiograms.

Choosing a Developer

Choosing a developer involves balancing contrast, speed, and graininess with cost, shelf life and ease of use. D11, D19, D76, and HC110 (all Kodak products) are examples of recommended developers (see Table 1).

D11 and D19 are active, high contrast developers. These developers combat the inherent low contrast of dye images. High contrast images are easier and quicker to read. Increasing the contrast between the dye filled blood vessels and fundus simplifies diagnosis. D11 and D19 produce high effective film speeds. Very little light is emitted by the fluorescein dye. The higher the effective film speed, the better the film is at conveying low light details. There is a drawback to using these high energy developers—they increase the graininess. This, in turn, can diminish the amount of fine detail perceived.

D76 and HC110 are less active developers. As a result, negatives developed in them have a more normal contrast (more intermediate greys) and finer grain than more active developers. D76 and HC110 also provide a lower effective film speed, unless they are used to overdevelop.

Overdeveloping, or pushing, a film consists of increasing the rate or time of developing. Increasing the rate of development can be accomplished by decreasing the dilution of the developer. Using D76 in its stock solution, rather than in a 1:1 dilution, is suggested by Zeiss when higher contrast negatives are needed.8

A rate increase in development can be accomplished by increasing the temperature of the solution. This technique is not often used because the emulsion of the film softens, allowing distortion of the image. The practical limit for film processing is 80° F.

Increasing the agitation of the film while in the developing solution increases the rate of reaction. Greater agitation allows fresh developer to come into contact with the film more often, and therefore increases the rate of the reaction. Small tank agitation is often 5 seconds duration every 30 seconds. Large tank (six or more reels) agitation is often 30 seconds duration every 60 seconds. Increasing small tank agitation is practical; increasing large tank agitation is not.

The most often used overdeveloping technique is increasing the time of development. Increasing development time makes a less active developer (i.e., D76) work more like an active developer (i.e., D11). Most developer/film combinations quote specific time/temperature recommendations. A good strategy for consistent results is to keep the dilution, temperature, and agitation constant, while fine tuning the time of development.

It should be noted that overdeveloping film changes the film's characteristics in the same way active film developers do. Overdevelopment increases contrast, effective film speed, and graininess. Your judgement determines whether the positive changes (contrast and effective film speed) outweigh the negative changes (high contrast and increased graininess).

Choosing a Development Time

Finding a development time which is appropriate for your darkroom and photographic equipment is a matter of making tests. Published recommendations for developer/time combinations may not be suitable with your photographic equipment. There are twenty-one different fundus cameras in use today, as well as various excitation/barrier filter combinations.[3,7] Each set of equipment exposes the film differently. Exposure predetermines the proper developer/time combination.

When experimenting, choose an exposure recommended by the manufacturer and a starting developer/time combination from Table 1. Standardize your dilution, temperature, and agitation. Alter the time of development until your negatives have a suitable density and contrast. A 10% change in temperature or time will yield a noticeable change in contrast and effective film speed. A 25% change will alter the contrast by one paper grade.6

Remember that extending development increases contrast and density. If your negatives are too thin, you will need to increase your exposure. The converse is also true. Very dense negatives need a decrease in exposure or a reduction in development time. Shortening development time also lowers contrast.

Summary

Inhouse processing of fluorescein angiography is a cost effective procedure. It is both uncomplicated and straightforward. The photographer can manipulate the procedure to control the enhancement or suppression of information. He does this by adjusting the developing agent and time of development. He can also change the dilution, temperature, or agitation. These procedural controls change the contrast, effective film speed, and graininess of the processed film. Experimentation, based on suggested developer/time combinations in this article, will yield high quality fluorescein angiograms.

References

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