Errors in Fundus Photography

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Introduction

High quality fundus photographs are useful as diagnostic and documentary tools. When problems in quality occur, it may be difficult to identify the cause of irregularity in the photograph. As with any multistep process, each act within the procedure can compound possible errors. Since each error can produce a corresponding artifact, a comprehensive approach to describing and cataloguing fundus photo errors is indicated.

Fundus photography is a specialized photographic process. Individuals without extensive training or photographic experience may be required to evaluate the adequacy of the final product. They may find it difficult to differentiate artifacts and identify their causes. Individuals with training and experience may not have a systematic approach to the characterization of fundus photograph errors. Health professionals who may benefit from this descriptive system include: *1)* The physician as evaluator: When the physician evaluates fundus photographs, he may not know the specific artifact producing situations that can be dealt with by the photographer. *2)* Novice fundus photographers: Beginning photographers (especially if from a nonphotographic background) may not be able to accurately evaluate and correct mistakes. 3) Photographer as trainer: Experienced photographers who train new fundus photographers can use this system to set minimum standards for entry into the field as competent fundus photographers. *4)* Photographer as manager: Photographers managing photographic departments need to exercise quality control judgements. 5) Photographer as repairman: Some fundus photograph artifacts are the result of faulty equipment.

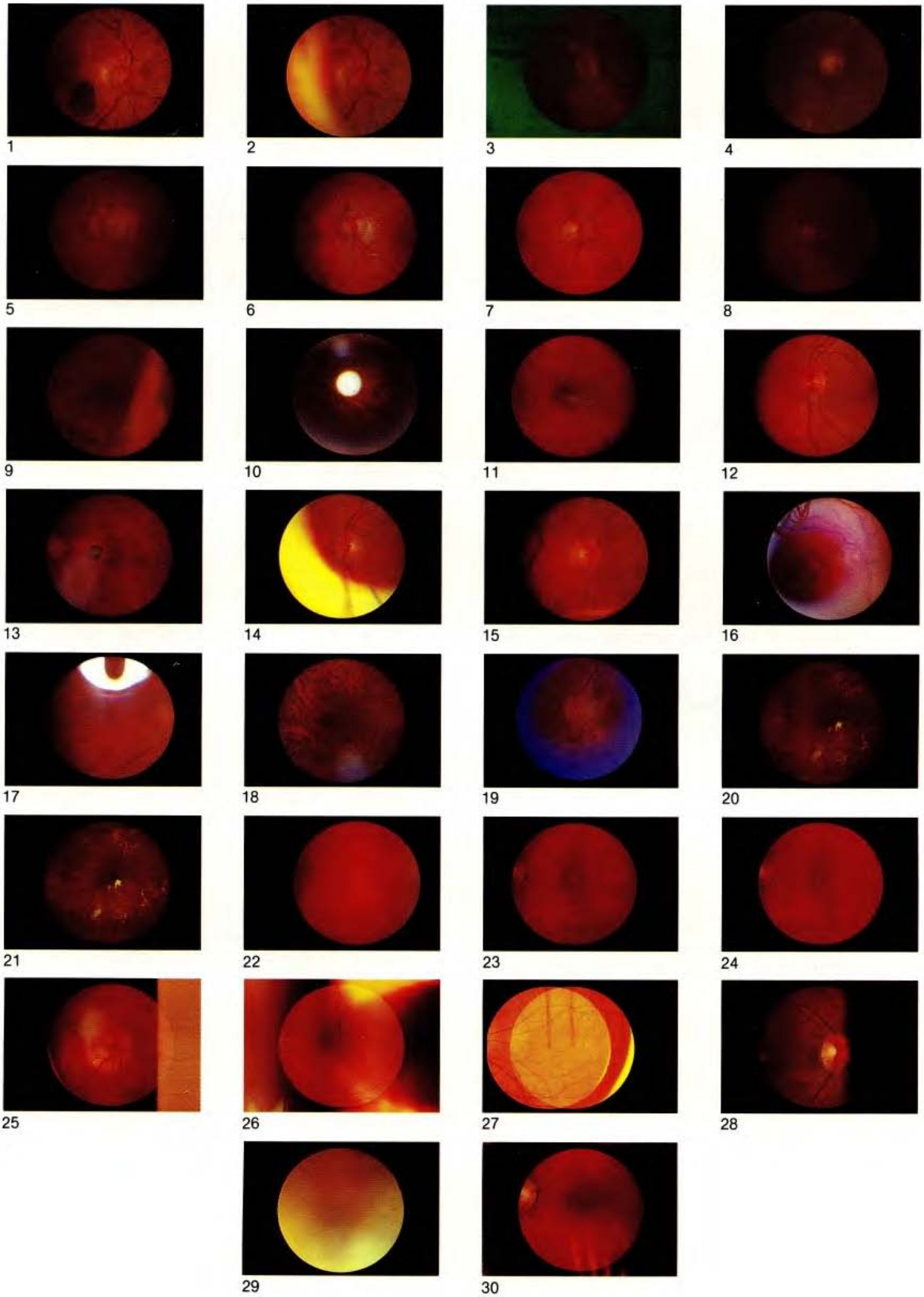
Fundus Photography

Quality fundus photographs are dependent on the optimal functioning of the photographer, the camera, and the patient. The photographer is responsible for:

1) Eliciting a cooperative response from the patient;
2) Appropriate alignment and setting of camera controls;
3) Pre and post photo session decisions (i.e., film choice and processing procedures).

The camera must faithfully translate an image of the fundus using integrated optical, mechanical and electrical subsystems. The patient contributes a cooperative attitude and clear media.

The goal of fundus photography is a final image which is a good representation of the photographed fundus. Figures 1 and 2 are of the same eye. An artifact obscures vital information in Fig. 2, illustrating the importance of artifact free photography. EXTENT describes the area the artifact occupies in the photograph. This processing error (3) involves the *full frame.* A vitreous hemorrhage (4) would obscure only the *full image area—and* notably not the black surround. Imperfect side to side alignment, when patients with certain intraocular lenses are photographed, can result in IOL shimmer. (5) shimmer, (6) same eye—correct alignment. Shooting around a cataract (7), as opposed to through (8) can eliminate some full image area artifacts. This multicolored crescent variation (9) is an example of a *partial image area* artifact. The rest of the fundus photograph is usable. Each artifact has a set of distinguishing features which describe the CHARACTER of the artifact. (10) a spectral reflectance is located centrally—haze is seen along the periphery of the image area. This artifact is the result of an excessive camera to subject distance. The *location* of the white area in (11) and (12) did not change: even though the location of the photographed fundus did. The artifact was caused by a smudge on the lens. Artifacts may be circular, crescent shaped or rectangular. This irregularly shaped blob (13) was from a blast of freon from "canned air". The crescent *shape* (14) and linear shape (15) are position related artifacts. Move the camera in the opposite direction of the artifact to eliminate. The white haze (16) from incorrect distance with an aphakic patient illustrates *overexposure.* This local overexposure (17) is the result of taking fundus photographs while a patient's, glasses are on. The light area in (18) represents a patient's eyelash or hair. Artifacts come in all *colors.* The characteristic blue haze (19) can be eliminated by changing the objective lens to cornea distance. Always look for an even, deep color through the viewfinder. An often overlooked artifact is the greenish cast **(20)** which occurs when color fundus photographs follow intravenous injection of 25% fluorescite. (21) is the result of better technique: taking color photos before the dye injection. *Unsharpness* can be caused by a number of situations including incorrect eyepiece settings and hazy media. **(22)** is an example of a cataract. **(23)** and (24) are examples of correct and incorrect settings of the astigmatism control. DISTRIBUTION: Loading film incorrectly can cause artifacts (25) in the *beginning* of the roll. Opening the camera back will cause a light leak (26) in the *middle* of the roll. A poorly adjusted motor drive can cause double exposures (27) at the *end* of the roll. Some artifacts occur with constant FREQUENCY. When an incorrect shutter speed is set, the shadow of the shutter curtain **(28)** will obscure a portion of the fundus in each and every succeeding frame until proper sync speed is restored. Artifacts may be confined to just one roll or to one patient. A photosensitive patient can cause blink artifacts **(29)** more often than other patients. Light leaks from an unsealed camera (30) will continue throughout fundus photographs regardless of a change in patient or film magazine.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Producing fundus photographs is a multistep process. The fundus camera generates a flash which is projected into the patient's eye, reflects off of the fundus then through the camera's optical system to the film. Each step in this process is potentially able to compromise image quality.

If we follow the pathway of image forming energy from its point of origin (the wall socket) to its final destination (the finished fundus photograph), we can identify specific problem areas where technical difficulties could occur.

Electrical energy flows from the socket to the flash generator where it is transformed and stored (interruption in each of these circuits are possible) until a signal is given for its release. After the photographer has properly adjusted the camera to the patient's eye (incorrect positioning and focusing are possible) a switch is closed and the stored electrical energy travels to the flash tube where it is transduced into light energy (malfunction in this process, such as a nonworking flash tube, is possible). This light energy passes through a series of condensers and lenses (all potentially dirty or out of alignment), out of the camera through the front element (a literal dust magnet) and across the air space between the camera lens and cornea (this space can be obstructed by hair, eyelashes, and eyelids). The projected light passes through the cornea, anterior chamber, lens and vitreous (all possibly in various states of opacification), then reflects off of the retina (which may be swollen or hidden from view by hemorrhage). The reflected light then passes back through the vitreous, lens, anterior chamber and cornea into the front element of the camera lens (multiplying any previous deleterious effects). The light is refracted through another series of lenses toward the camera. Just as the light reaches the camera body, the shutter opens and closes (timing may be off) allowing the light to modify the chemical nature of the film (assuming the film is correctly chosen and loaded). Once sensitized, the emulsion is processed (another complex process with its own long list of possible errors). This image pathway is, of course, dependent on a camera which is aligned correctly with the patient, and a patient/photographer relationship which will enhance this alignment.

The goal of this process is a final image which is a good representation of the photographed fundus. Artifacts, when present, are portions of the image arising from the process itself, rather than from the object being recorded. Just as a correct diagnosis from a fluorescein angiogram requires first a proper description of hypo/hyper fluorescence, describing artifacts is the first step in determining the cause of fundus photograph errors.

Descriptors

Four essential details should be included in each description of the imperfect fundus photograph: the extent and character of the artifact, and the distribution and frequency of the affected slide in relation to other fundus photos in the same or adjacent rolls. Suggested descriptors are contained in the list below.

Extent:

Full frame—no useful information

Full image area—no useful information within standard fundus image area, but black surround is left unaffected.

Partial image area—artifact obscures a portion of the image area, while remaining area is of adequate quality.

Character:

Location—central or peripheral within image area; superior, inferior, to the right or left.

Shape—circular, crescent, or rectangular. Edges may be fuzzy or sharp.

Exposure—overall photograph may be too light or dark. A double exposure may be in evidence.

Color—the artifact may be any color; white, yellow, orange, and blue are common. Multi colored artifacts are possible, as is a colored haze.

Sharpness—the full image area may be sharp or unsharp, as can portions thereof.

Distribution:

Beginning of roll, middle of roll, end of roll.

Frequency:

Random or regular; throughout one roll or one patient, crossing several rolls or patients; occasionally, frequently, once.

Examples

Illustrations 1 through 30 are examples of common artifacts. Captions exemplify correct usage of descriptors, and note the usual cause of the illustrated artifact.

Summary

Imperfect conditions while making fundus photographs cause artifacts in the resulting images. Certain health professionals need to discriminate between artifacts in order to effectively evaluate fundus photography. A vocabulary for describing the artifacts is presented. Common examples are shown and their usual causes discussed.

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