Clinical and diagnostic color-coding in ophthalmology - An indispensable educational tool for ophthalmologists

Deepak Mishra, Kirandeep Kaur¹, Bharat Gurnani², Aarti Heda³, Kshama Dwivedi⁴

Schematic diagrams have been important tools in Ophthalmology for ages. These are vital tools to document ocular pathologies, assist in the comparison of clinical records on follow-up visits, serve as standardized means of communication between ophthalmologists, educating trainees and postgraduates, and helping in the easy follow-up of disease course over a period. There are standardized color codes for depicting different pathologies in the anterior and posterior segments. The understanding of these guidelines allows proper documentation of findings and helps in standardizing ophthalmic care. This method of documentation is beneficial as this is a less expensive tool, provides immediate records at a glance, allows distinctive marking of clinical findings not possible to document with clinical photographs, and can help in medico-legal cases as well. This article focuses on highlighting the standard guidelines that will be useful for training ophthalmologists. This article primarily focuses on various color-codings for anterior and posterior segment schematic representations, along with a brief touch on the importance of color-coding in glaucoma and standardized eye drop (vials) color codes as per the American Academy of Ophthalmology guidelines. We believe this can be taken as a template for future reference by all trainees, postgraduates, fellows, and clinician ophthalmologists in their day-to-day clinical practice.

Key words: Anterior segment diagram, color-coding, retinal diagram, schematic diagram

Documentation is merely a requirement in every job, however, in healthcare, it forms a vital part of each member’s role.[1] Schematic documentation has been a cornerstone of clinical science from the days of Hippocrates.[2] This has helped in not only standardizing the records but has also assisted us in understanding the disease process over time, maintain records, and at the same time, helped in easy cross-referrals across the globe. There are many vital moments during the treatment of any ocular pathology.[3] Proper documentation can help the practitioners to recall those moments and plan treatment accordingly. No or poor documentation reduces the value of any clinical records. Moreover, inaccurate or incomplete documentation is a threat to patient safety and hampers the defense of a medical malpractice lawsuit.[4]

Documentation is a simple but effective tool that can help any practitioner in unveiling clinical patterns. It can help track the progression or regression of any ocular pathology on subsequent follow-ups.[5] It also helps in understanding patterns of clinical presentation and also any associated unhealthy behaviors like contact lens use.[6] Documentation is often the sole way of communication whenever treatment protocol changes among practitioners. For patients, documentation ensures the delivery of safe, precise, consistent, and quality healthcare.[7]

In this digital era, the introduction of the Electronic Medical Record (EMR) system was a landmark attempt to improve the documentation and allow easy access to old records of the patient. King et al.[8] in their study found that the physicians reported the use of Electronic Health Records (EHR)-enhanced patient care overall. Clinical benefits were most likely to be reported by physicians having longer EHR experience.

The history of standardizing color-coding in Ophthalmology dates back to 1969 when Schepens described the graphic documentation of retinal disorders.[9] This was followed by an article in 1973, where for the first time, a scheme for documenting corneal diseases was described.[10] This was improvised by Waring et al.[11] in 1977 wherein they described frontal and slit sketches for documentation of corneal pathologies. Bühren et al.[12] in 2006 described the colored standardized drawing scheme to document corneal changes following refractive surgery. It is very important to inculcate the habit of proper documentation from the beginning of our medical career. This is extremely vital in the field of Ophthalmology, where the eye being a small and compact structure has innumerable microscopic findings for which documentation with standardized color-coding becomes vital for quality patient care.[13]

Color-coding is particularly more important in the current COVID-19 pandemic, as there are delayed presentations...
by patients secondary to lockdown and fear of acquiring COVID-19 infection in the hospital settings. Schematic
documentation of the anterior and posterior segment
findings, particularly in cases of corneal ulcers, diabetes, or
hypertensive retinopathy will help in correlating the clinical
findings even after delayed follow-ups. COVID-19 has come
with a lot of challenges for postgraduate training. But it is
important to understand that training in proper documentation
with illustrative standardized diagrams is as important as a
wet lab and surgical training to bring out competent
ophthalmologists. As per the detailed literature review, this
is the first article related to Ophthalmology documenting the
color-coding for schematic documentation in detail. In this
article, we have attempted to summarize the standardized
color-coding systems in ophthalmology. We believe this will
be very useful not only for trainees in ophthalmology but also
for established ophthalmologists to recollect the old knowledge
and ensure proper documentation of the clinical findings

Why is Schematic Documentation Important in Ophthalmology?
The need for diagrammatic representation has been long
emphasized. Dvorak et al. described drawing as a lost art of
medicine and emphasized the role of mapping retinal tears,
detachments, and landmarks before surgical detachment repair.
The sketch of the eye allows the ophthalmologist to accurately
describe the size, depth, and location of the lesion. Proper clinical
documentation at each visit ensures better management of the
disease as it allows comparison with the previous records. The
information becomes further valuable when a patient is
followed for a long time and cannot follow-up at a major
center for close follow-ups. A trained ophthalmologist in a
rural setting can document findings at each visit and maintain
regular records till he feels the patient needs a referral to a
higher center. Thus, it creates a standardized method of
documentation and helps not only in proper management,
but also comes as a savior from medico-legal issues as well.
Documentation with schematic diagrams also helps in educating the
trainee in ocular anatomy along with the use of slit-lamp and
binocular indirect ophthalmoscope. It helps to document the
pathology in a more detailed manner as compared to clinical
photographs. It is less expensive, allows standardization of
documentation, is easy to follow-up, is a useful teaching
modality, and presents a total picture at a glance.

Color-Coding in Clinical Ophthalmology
Anterior segment
The requisites for drawing include six colored pencils or pens
such as black, blue, brown, red, green, and yellow and an eraser
to allow modifications of drawing. There are some stencils
available commercially which aid in the quick reproduction of
cornea and retina diagrams, front of eye, and slit shape outlines.
First, we need to sketch the major landmark and then details
should be filled in. Corneal pathologies are documented on a
frontal plane and a cross-sectional or slit plane. The cornea is
depicted in plain view by a circle. Vessels drawn inside the
circle are, therefore, pathological. To depict the vessels of the
limbal paliades, these must be drawn outside the circle, as
must, other limbal features such as limbal infiltrate and follicles.
A corneal cross-section is drawn as two parallel arcs with
freehand in a black outline. This allows a more accurate
representation of the variation in corneal thickness, such as
anterior ulceration, the posterior bulge of stromal edema, or
diffuse thinning. Another wavy line along the anterior corneal
surface represents the epithelium. The clinical findings like
epithelial defects, microcysts, edema, bullae, opacities, and discontinuity are depicted on this wavy line. A single black line
represents the endothelium and Descemet’s membrane. In the
presence of a dense stromal opacity, the posterior corneal surface
is represented by a dotted line with appropriate annotation. The depth of corneal pathology can be depicted in the slit diagram.

Following color-coding is generally used to document the
findings of the anterior segment. Black color is used to
develop limbus, scars, degenations, dystrophy, foreign
bodies, sutures, contact lens, and band-shaped keratopathy.
The blue color is used to represent the stromal edema, epithelial
edema, Descemet’s membrane folds, and epithelial bulla. The
brown color is used to represent epithelial iron lines, epithelial
melanosis, pupil and iris, iridodialysis, iris nodules, old keratic
precipitates, and Kruckenberg’s spindle. The red color is used
to depict blood vessels. The superficial vessels are drawn starting
outside the limbal line while the deep vessels arise at the limbal
line. Further, the subepithelial vessels are depicted as wavy
to lines and begin outside the limbal circle. While the stromal
vessels are depicted as straight lines and begin at the margin of
the limbal circle. Other findings depicted in red include ghost
vessels, ciliary or conjunctival congestion, hemorrhages, and
hyphemas. The green color is used to depict filaments (line),
punctate epithelial keratopathy (dots), epithelial defect (shades),
dendrites, lenticular changes, and vitreous strands in the
anterior chamber. The yellow color is used to depict hypopyon,
infiltrates and fresh keratic precipitates. The details of the
anterior segment color-coding are described in Table 1. Detailed
anterior segment drawing with commonly encountered clinical
findings has been illustrated in Fig. 1.

Posterior segment
The prerequisites for fundus drawing include an examination
table, indirect ophthalmoscope, +20 D lens, scleral depressor,
colored pencils (red, blue, green, yellow, black, and brown),
an eraser, and a fundus drawing chart. The standard fundus
drawing chart called as Amsler–Dubois chart contains three
concentric circles. The innermost circle on the chart represents
the equator, the middle circle represents the ora serrata, and
the outer circle represents the junction between the pars plana
and the pars plicata. The optic nerve head is represented as
a small circle. The macula is drawn in the center, and the optic
to nerve head is located nasal to the macula. The radial Roman
numerals on the outer circle of the chart are useful to explain
the location and also the extent of the lesions in clock hours.

During the examination, the patient should be lying down
comfortably with a well-dilated pupil. The peripheral retina
should be examined first as it is less sensitive to light than the
posterior pole. To trace the lesion, the disc is first focused and
followed along the blood vessel to the periphery. To replicate
the clinical examination findings on Amsler’s chart, the bottom
right-hand corner of the chart is kept next to the patient’s right
shoulder. This is especially important in the early training period
and helps to overcome the difficulties due to the inverted and
reversed images perceived by the observer during indirect
ophthalmoscopy.

The following color-coding is used to describe the findings
of the posterior segment. The red color is used to depict
the retinal arterioles, elevated neovascularization, vascular
abnormalities\ anomalies, vascular tumors, vortex veins,
attached retina, hemorrhages (pre-retinal and intraretinal,
Table 1: Showing detailed color-coding guidelines for anterior segment schematic representation

| Ocular Structure | Color | Anterior Segment Structure or Pathology |
|------------------|-------|----------------------------------------|
| Cornea           | Black | Scars, degenerations, dystrophy, foreign bodies, sutures, contact lens, band keratopathy |
|                 | Blue  | Diffuse stromal edema (shading), epithelial edema (small circles), folds in Descemet’s membrane (wavy lines), and epithelial bulla (omega -on slit view) |
| Brown            |       | Epithelial iron lines, epithelial melanosis, old keratic precipitates, and Krukenberg’s spindle. |
| Red              |       | Blood vessels, rose Bengal staining (dots), ghost vessels (straight dotted lines), congestion (ciliary, conjunctival, and mixed), hemorrhages. |
| Green            | Filaments (line), punctate epithelial keratopathy (dots), epithelial defect (shades), dendrites, lenticular changes |
| Yellow           |       | Hypopyon, infiltrates, and fresh keratic precipitates |
| Pupil            | Brown |                                      |
| Limbus           | Black |                                      |
| Anterior Chamber (AC) | Red | Hyphema |
|                   | Green | Vitreous in AC |
| Iris              | Brown | Iridodialysis, and iris nodules, anterior or posterior synechiae |
| Lens              | Green | Lens |
|                   | Black | IOL |

subhyaloid), the open interior of retinal breaks (tears, holes), the open interior of outer layer holes in retinoschisis, normal macula, macular edema (blue/red cross with four adjacent blue dots), open portion of a giant retinal tear, retinal holes, large dialyses, inner portions of thinned retinal areas, and the open part of retinal holes in the inner layer of retinoschisis. The blue color is used to depict areas of a detached retina, retinal veins, outlines of retinal breaks, outline of ora serrate, meridional, radial, fixed and circumferential folds, traction tufts, retinal granular tags and tufts, the outline of flat neovascularization, the outline of lattice degeneration, the outline of thin areas of the retina, and intraretinal cysts, the inner layer of retinoschisis, white with or without pressure, detached pars plana epithelium anterior to the separation of ora serrate, rolled edges of retinal tears, cystoid degeneration, and areas of the detached retina. The green color is used to depict opacities in the media, vitreous hemorrhage, vitreous membranes, hyaloid ring, intraocular foreign body, retinal operculum, cotton wool spots, and outline of elevated neovascularization, asteroid hyalosis, snowflakes on cystoid degenerations, retinoschisis, or lattice degeneration.

The brown color is used to represent uveal tissue, pars plana cysts, ciliary processes, striae ciliaris, pigment beneath the detached retina, the outline of chorioretinal atrophy beneath the detached retina, pigment epithelial detachment, the outline of posterior staphyloma, malignant choroidal melanomas, edge of buckle beneath the detached retina, and choroidal detachment. The yellow color represents intraretinal edema, intraretinal subretinal hard exudate, deposits in the retinal pigment epithelium, detached maculae, retinal separations, post-cryotherapy or laser retinal edema, drusens, long and short ciliary nerves, venous sheathing, and drusens. The black color is used to represent the edge of the buckle beneath the attached retina, the outline of chorioretinal atrophy, hyperpigmentation as a result of the previous treatment with cryotherapy or diathermy, naevi, sclerosed vessels, the outline of long and short post-ciliary vein and nerve, the pigment in the choroid, or pigmented epithelial hyperpigmentation in areas of the attached retina, the pigment in the detached retina, pigmented demarcation lines at the attached margin of a detached retina or within the detached retina.

The choroidal tumors are drawn in brown color and retinoblastomas are outlined with blue and colored in yellow color. For retinoschisis, the inner layer is outlined and cross-lined using blue color. While the open retinal holes within the inner layer are outlined in blue with the inner portion cross-lined in red, the holes in the outer layer are outlined in blue and the inner layer is colored red. The details of the posterior segment color-coding are described in Table 2. Detailed posterior segment drawings with commonly encountered clinical findings have been illustrated in Fig. 2 a and b.

Color-Coding in Diagnostic Ophthalmology

Glaucoma

Clinically, for depicting optic nerve head changes in glaucoma, the disc is drawn as a circle with black color, the cup is shaded in yellow, the dichotomous arterial branching is depicted with red color, and the veins in blue color. The splinter or Drance hemorrhage as observed in normal-tension glaucoma is drawn with red and the retinal nerve fiber layer defect in green.

Ophthalmic imaging techniques such as optical coherence tomography (OCT) allow objective, quantitative evaluation of ocular structures. OCT has been shown to correlate well with histological retinal measurements and to allow direct visualization and quantification of the structures of the retina and optic nerve head. This device is a valuable tool for detecting glaucoma and monitoring its progression. The retinal nerve fiber layer thicknesses and optic nerve head in the normal range are represented by green backgrounds, those that are abnormal at the 5% level (borderline) are represented by yellow backgrounds, and those that are abnormal at the 1% level (below normality) are represented by red backgrounds. The white color code refers to values above the normality range, and the grey color indicates that normative data are not applicable.

Cornea

Color-coded topographic maps

In Schiempflug imaging systems like Pentacam and Orbscan, the color-coded topographic maps display the contour and give valuable information regarding varied corneal pathologies like corneal ectasia (keratoconus, pellucid marginal degeneration, terrain marginal degeneration), thinning, thickening, astigmatism, post LASIK ectasia, etc.[31] The hot colors like red and its various shades represent the steep areas in the cornea. The cool colors like blue and its various shades indicate the flat portion of the cornea. Hence, the colors from red-orange-yellow-green-purple-blue progressively denote the lesser refractive power.[32]

Color-coded scales

These scales are a must-know before interpreting a color map. If the scales are different, two similar-looking color-coded
maps will reveal different information. There are two types of color-coded scales: absolute and normalized scales. In an absolute scale, each color denotes an interval of 1.5 D starting from 35 to 50 D, where the higher and lower than this range represent an interval of 5 D. This scale is commonly used in preoperative screening with the only demerit that it does not denote subtle changes in the curvature. In a normalized scale, the cornea is split into 11 equal colors considering the eye’s total dioptric power. This scale gives the advantage of depicting minute topographic changes and a more intricate description of surface changes. The disadvantage is that the color of two different maps are not comparable directly and need keratometric values for comparison.

**Color-coding for ophthalmic drops**

With almost 400,000 drug-related injuries occurring each year in the US hospitals, medical errors continue to increase at an alarming rate with significant morbidity and mortality. For patients in the hospital setting, it is estimated that one medication
Figure 2: (a and b) Detailed posterior segment pictorial representation of commonly encountered clinical findings
error happens at least once a day.\[34\] The American Academy of Ophthalmology (AAO) has been attempting to reduce errors in ophthalmic drops since the mid-’90s with the advocacy of a uniform color-coded system for topical ocular medications.\[35\] This standardized color-coding is expected to help patients and the healthcare providers identify medications correctly and thus reduce errors both inpatient and outpatient.\[36\] The details of color-coding as per the AAO have been listed in Table 3.

Though this color-coding is widely accepted and adopted in developed nations like the USA, we are yet to adopt this coding system in our country.\[37\] With proper utilization of the color-coded system, an appropriate judgment about which ophthalmological medications a patient utilizes can be made.\[38\] This would help the emergency physicians obtain a better understanding of their current presentation and prevent iatrogenic harm. But, this color-coded system is not foolproof and the potential for error in medication administration still exists.\[39\] Therefore, a good clinical judgment and familiarity with the active ingredient in each topical medication should always be maintained.\[40\]
**Conclusion**

To conclude, schematic representation of ocular findings is a skill, which should be acquired and practiced by all from the early days of training itself. Recording of corneal and retinal findings following the standard scheme of color-coding will allow better communication between ophthalmologists, enhance the understanding of the disease course, and improves the observation with slit-lamp by accurately sketching what he/she observes. This is particularly even more important in the present COVID-19 times, as there are reported delayed presentations by patients.\(^{[30]}\) Schematic representations of the anterior and posterior segment findings can help ophthalmologists correlate the clinical status in a better way. Further, this is non-expensive, needs no extra expensive cameras, and allows a glance of the past findings and the course of the disease. We together should make efforts to inculcate the habit of schematic representations of all clinical examination findings and make a system of proper documentation on subsequent visits for generations to follow.

**Consent for publication**

The article does not involve any data from subjects. Hence exempted from prior patient consent.

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There are no conflicts of interest.

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