DIGITAL IMAGING IN OPHTHALMOLOGY

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SUMMARY – In recent years, digital photo equipment has developed a high quality of photographs which are more than useable for specialist analysis. The possibility of attaching the digital photo equipment on numerous ophthalmic instruments; like slit lamp biomicroscope, fundus camera, microscope etc. – gives as a new dimension and quality of examination. Digitally stored images can be easily accessed on a computer and allow us to compare electronically patient‘s check-ups; to monitor his/her treatment plan; or can be transmitted anywhere for telemedicine purposes. Having the images immediately on screen allows us to explain the problem and treatment goals better to our patients, and we can provide the images quicker to the referring physicians. The digital system often allows us to treat the problem on the same day, so patients don't have to make another appointment. Another advantage is that new images can be superimposed on the old ones for the comparasion, enabling in this way a better monitoring of patient‘s condition over certain time. Also, if photographic-quality prints are needed it is possible to print out. The instantaneous availability of digital information, low cost per photograph, the rapid transfer, easy storage and managing in computer database are major advantages of digital imaging over standard 35-mm film processing.

Key words: *Digital imaging, telemedicine, ophthalmology*

A continued growth and development in ophthalmology can most effectively be achieved through the use of photo documentation. Ophthalmic photography is a highly specialized form of medical imaging dedicated to the study and treatment of disorders of the eye.[1] The use of digital imaging products lets us build an extensive library of assets from which we can refer and continue to learn from in order to treat our patients with the best care possible. Digitally stored images can be easily managed on a computer and allow us to electronically compare patient‘s check-ups to monitor his/her treatment plan.[2,3]

Developing telecommunication techonologies offer new ways for improving health care to individuals in remote communities and usefulness of telemedicine. Telemedicine technologies are applicable in ophthalmology, because most of the standard ophthalmic instruments can be modifed to capture digital images and store them in a computer database; then they can be transmitted for expert evaluation.[4,5] Many studies today use digital imaging for screening of diabetic retinopathy and management of many other ophthalmic disorders like retinopathy of prematurity, strabismus, age-related macular degeneration etc. [6,7,8] The quality and cost comparasion studies of 35-mm film with colour digital fundus images have been also performed. The main conclusion, is that the quality of digital images is acceptable for diagnostic purposes although resolution is limited. Other advantages and developing technologies with megapixel cameras will make it increasingly attractive in the future.[9,10]

A horizontally mounted microscope, coupled with special illumination devices is used to photograph the cornea and antherior eye segment. This photo slit lamp with digital photo equipment produces high magnification viewes of disorders and high quality photographs that would be impossible to observe with the naked eye.[11]

Some diagnostic procedures like fluorescein angiography (FAG) with digital imaging systems have proven to be much more appropriate in clinical practice. Angiography

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is the imaging of vessels, and the resulting pictures are angiograms. Angiography of the retina of the eye requires the injection of a small amount of dye into a vein in the patient's arm. The dye travels through the blood stream and is photographed with special cameras and color of light as it travels through the vessels of retina.[12]

Digital imaging systems allow the image to be viewed as the test is being done. Digital cameras can be adjusted to high sensitivities which allow the dye to be captured even when it grows very dim. Digitally stored images can be easily managed on a computer and allow us to electronically compare patient's check-ups in order to monitor his/her treatment plan, or can be transmitted anywhere for telemedicine purposes. Having the images immediately on screen allows us to explain the problem and treatment goals better to our patinets, and we can provide the images quicker to the referring physicians. The digital system often allows us to treat the problem on the same day so patients don't have to make another appointment. Also, if photographic-quality prints are needed it is possible to print them out.

Indocyanine Green (ICG) dye is used in conjuction with infra red "light" for angiography in very special cases where fluorescein angiography proves inadequate. Because infrared energy is not in the visible spectrum and can not be imaged well with photographic film, high-sensitivity digital cameras are used for ICG angiography.

Optical Coherence Tomographer (OCT) is the ophthalmic instrument which acquires two-dimensional cross-sectional cuts of the retina by receiving the reflected light, and can yield thickness data to within 10 mm. The resolution of the resulting image depends on the coherence of

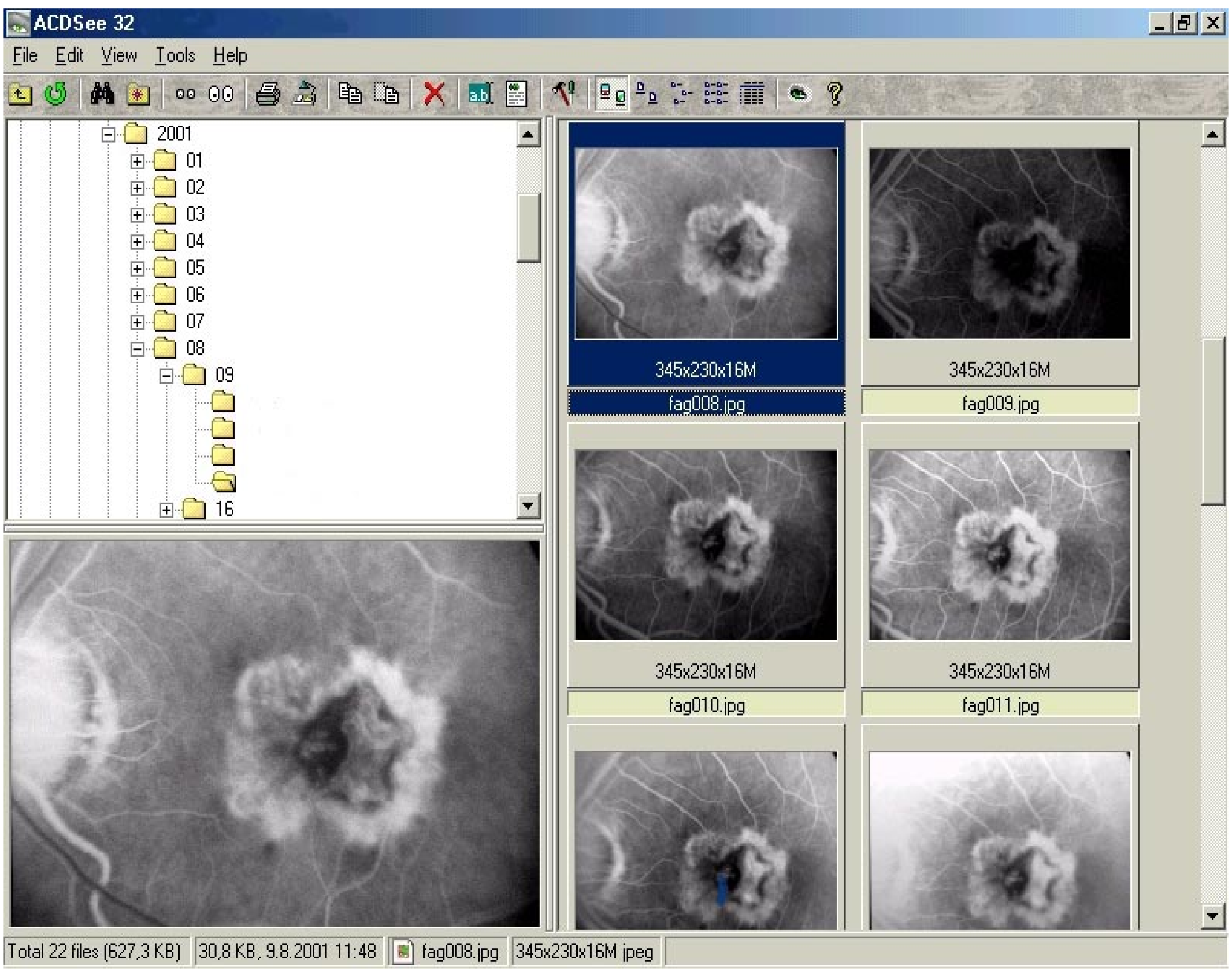

Fig. 1.

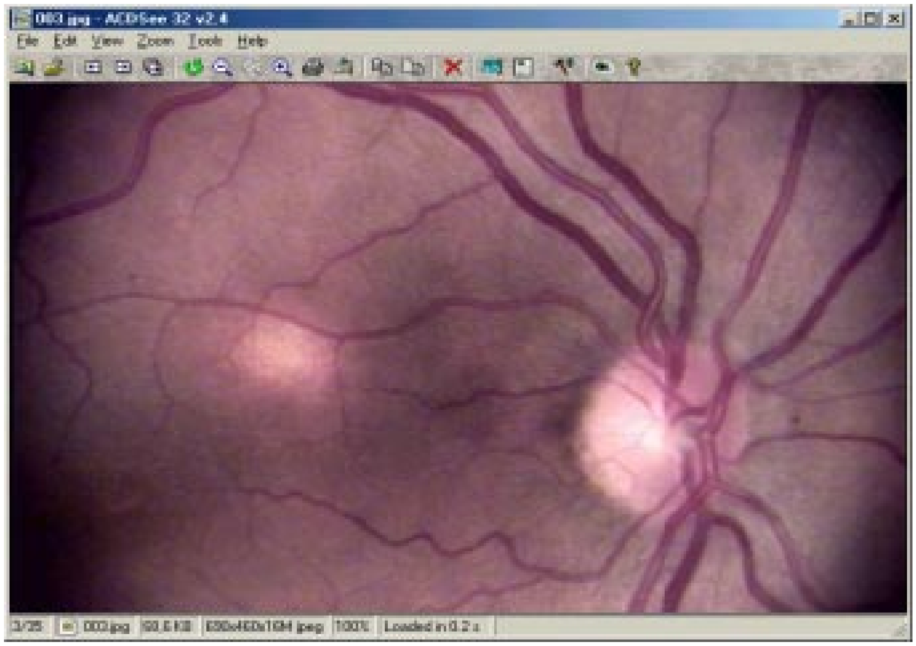

Fig. 2.

the light source. The OCT's imaging powers have proven useful in two major categories of disease: Macular edema and conditions of vitroretinal traction, such as macular hole and macular pucker. In cases of epiretinal membrane, it also provides very distinctive images Some diagnostic procedures like fluorescein angiography (FAG) with digital imaging systems have proven to be much more appropriate in clinical practice. Angiography is the imaging of vessels, and the resulting pictures are angiograms. Angiography of the retina of the eye requires the injection of a small amount of dye into a vein in the patient's arm. The dye travels through the blood stream and is photographed with special cameras and color of light as it travels through the vessels of retina.[13] It has also helped us differentiate between macular hole and vitreomacular traction syndrome, and allows us to tell if we're looking at cystoid macular edema or macular pucker in diabetics.

Fundus image can also be recorded using a confocal scanning laser ophthalmoscope (SLO). Scanning laser imaging technology is quite different than that of the conventional fundus camera system. A laser beam of the appropriate wavelenght scans across the fundus in a raster pattern to illuminate successive elements of the retina. The scan rate of the laser is synchronized at 30 frames per second, a rate that is compatible with video display. This imaging technique provides a continuous, real time representation of the flow dynamics of the retina and choroid. The SLO lessens the need for pupillary dilation and patients can easily tolerate the low light level of the laser. The major drawback of scanning laser technology is the high cost of the equipment.

The Heidelberg retina Tomograph (HRT) uses a confocal scanning laser to acquire and analyze three-dimensional sections of the retina through an undilated pupil. To acquire an image, the HRT uses a 670-nm diode laser that is periodically deflected by oscillating mirrors. As the laser scans the retina at these different angles, the instrument measures the reflectance that occurs at particular focal planes, constructing a series of two-dimensional images at different depths. By combininig the images, the device can create a multi-layer three dimensional topographical image. It can also compute the retinal surface height at each point. The measurements have a reproducibility of around 20 mm at each point Some diagnostic procedures like fluorescein angiography (FAG) with digital imaging systems have proven to be much more appropriate in clinical practice. Angiography is the imaging of vessels, and the resulting pictures are angiograms. Angiography of the retina of the eye requires the injection of a small amount of dye into a vein in the patient's arm. The dye travels through the blood stream and is photographed with special cameras and color of light as it travels through the vessels of retina.[14]

The Retinal Thickness analyzer (RTA) is relatively new addition to the digital ophthalmology imaging. It seems to be promising for the management of macular pathology. The RTA uses a HeNe laser to scan a central 2 mm × 2 mm area. As it scans, it receives two reflections, one from the internal limiting mambrane, and one from the retinal pigment epithelium. The computer then maps the distance between these layers and generates a thickness contour map of the retina inbetween. One potentially exciting area is the detection of diabetic macular edema. The RTA may also be helpful in early diagnosis of choroidal neovascularization in age-related macular degeneration patients Some diagnostic procedures like fluorescein angiography (FAG) with digital imaging systems have proven to be much more appropriate in clinical practice. Angiography is the imaging of vessels, and the resulting pictures are angiograms. Angiography of the retina of the eye requires the injection of a small amount of dye into a vein in the patient's arm. The dye travels through the blood stream and is photographed with special cameras and color of light as it travels through the vessels of retina.[15]

The Topographic Scanning System (TopSS) uses an infrared diode laser to create a 32-layer image of the retina with over two milion data points. It then combines these to form a three dimensional image, complete with depth information. One condition with which it has been helpful is central serous chorioretinopathy and the TopSS can be useful in the early detection of changes in the glaucomatous optic disc Some diagnostic procedures like fluorescein angiography (FAG) with digital imaging systems have proven to be much more appropriate in clinical practice. Angiography is the imaging of vessels, and the resulting pictures are angiograms. Angiography of the retina of the eye requires the injection of a small amount of dye into a vein in the patient's arm. The dye travels through the blood stream and is photographed with special cameras and color of light as it travels through the vessels of retina.[16]

Commercial digital imaging systems have been available for over fifteen years and continue to improve in quality each year. Although photographic film is still capable of capturing greater detail than current digital systems, digital imaging offers some distinct advantages over the more traditional film-based process. Instant access to the digital images increases efficiency and promotes better patient eduaction by reviewing images on a monitor with the patient. Image enhancement and manipulation is easily achieved with imaging software. Lesions can be measured, or digital overlays used to identify changes in lesion size in serial photographs. Images can be stored on magnetic or optical media like CD-ROMs and transmitted electronically to remote sites equipped with a computer for viewing. Digital systems also offer the additional advantage of shortening the learning curve for novice angiographers. Having instant feedback allows the physician to adjust exposure settings and camera alignment to correct any flaws in technique. Despite these advantages, the high initial cost of digital systems has prevented them from being employed universally.

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Sažetak

DIGITALNA FOTOGRAFIJA U OFTALMOLOGIJI

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Posljednjih nekoliko godina oprema za digitalnu fotografiju je dosegla visoku kvalitetu fotografija, koja je više nego dovoljna za specijalističku analizu.

Mogućnost dogradnje opreme za digitalnu fotografiju na brojne oftalmološke instrumente poput biomikroskopa s procijepnim svijetlom, kamera za snimanje očne pozadine, mikroskopa i sl. daje novu dimenziju i kvalitetu pregleda bolesnika. Digitalno pohranjene slike mogu se jednostavno koristiti na računalu i omogućavaju nam jednostavnu usporedbu bolesnikovih posjeta i praćenje liječenja. Isto tako mogu se prenositi u telemedicinske svrhe. Trenutna mogućnost prikaza slike na monitoru računala omogućava nam da bolje razjasnimo pojedini problem i pristupimo liječenju bolesnika istog dana tako da bolesnik ne mora dolaziti ponovo. Druga prednost je što se digitalne fotografije mogu lako superponirati jedna preko druge radi usporedbe s prethodnim nalazom, što uvelike poboljšava kvalitetu praćenja bolesnika. Isto tako, ako je potrebno moguće je ispisati fotografije u vrhunskoj kvaliteti. Mogućnost trenutnog prikaza slike, mala cijena po pojedinoj fotografiji, brza mogućnost prijenosa, jednostavno pohranjivanje i pregled u računalnim bazama podataka glavne su prednosti digitalne fotografije naspram standardnog 35-mm fotografskog filma.

Ključne riječi: *digitalna fotografija, telemedicina, oftalmologija*