Do we need Wide-Field Retinal Imaging?

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How Far is Wide-Field?: Viewing the Vortex Ampullae
Wide-angle noncontact and small-angle contact cameras

Oleg Pomerantzeff

The theoretical wide-angle model of the human eye and the principle of operation of ophthalmoscopic illumination and observation apertures have been used to design two fundamentally different ophthalmoscopic cameras: a 90° wide-angle, noncontact camera and a high-resolution macula-disk camera. The chief advantages of the 90° noncontact camera is the increase in contrast achieved by eliminating from the retinal image light reflections off corneal and limbal surfaces. This contrast increase is obtained in addition to a wide-angle field, while the resolution of current fundus cameras is maintained. The chief advantage of the macula-disk camera is that it records the first image of the patient’s fundus and thus permits an actual increase in resolution of retinal detail not obtainable with current fundus cameras. This additional detail should greatly facilitate future clinical study and treatment of macular diseases.

Key words: fundus photography, macular angiography, magnification, contact camera, 90° field noncontact camera

Two opposite trends exist in fundus photography: (1) increase in magnification, which clarifies small, possibly microscopic, details, and (2) increase in the observed field, which reveals the overall pathology of the fundus by disclosing the relative location and size of different structures in the fundus. Various contact and noncontact cameras have been proposed with fields (measured from the nodal point of the eye) of 30° (Fundus Flash 3, Carl Zeiss, Inc., New York, N. Y.; TRC-F3, Topcon Instrument Corp. of America, Paramus, N. J.; 45° (Kowa BC-W, Kowa Company, Ltd., Tokyo, Japan; Retinamap 45-H, Nippon Kogaku U.S.A., Inc., Garden City, N. Y.); 60° (Zoom Retinal Camera CR-60Z, Canon U.S.A., Inc., Long Island, N. Y.); 100° (Fundus Camera CA-2, Clinten, Danvers, Mass.); and 145° (Pomerantzeff Equator-Plus Fundus Camera, Medical Instrument Research Associates, Waltham, Mass.).

To date, a field of more than 60° has been obtained only with contact cameras, i.e., with the objective lens (ophthalmoscopic lens, OL) touching the patient’s cornea. Applying our theory of image formation in fundus photography, we have designed a noncontact 90° camera that will be discussed briefly in this report.

So far, greater magnification has been realized only through increasing the magnification of the recording camera, thus magnifying one part of the intermediate aerial image without changing the objective of the fundus camera (OL). As has been stated, the only information on the retina that the fundus camera can provide is contained in the aerial image formed by the OL. Hence, magnifying this image by the recording optics instead of enlarging the negative has only the...
Panoret

- Medibell Medical Vision Technologies Ltd
- Early 2000s
- Named for capturing "panoramic" retinal images
- Handheld Fundus camera
- Transscleral Fiber Optic illumination
- 130 degree field of view
ULTRA-WIDE ANGLE IMAGING SYSTEMS

- POMERANTZEFF CAMERA®
- PANORET-1000 CAMERA®
- STAURENGHI LENS®
- RETCAM®
- OPTOS®
- SPECTRALIS®
Spectralis® Ultra Widefield Lens
Spectralis® non-Contact Widefield FFA

Widefield

30° lens

55° lens

Retinal Vein Occlusion
Retcam®:
Contact Method
Paeds or GA patients
Retcam® Imaging
Optomap® Imaging

- SLO using 2 laser wavelengths
  - Green (532 nm)
  - Red (633 nm)
- Superimposition of wavelengths – colour
- Individual wavelengths:
  - red-free (green laser)
  - green free (red laser)
- Autofluorescence
  - 532 nm excitation
- Parabolic mirror
  - 180 – 200° field
- Images acquired in 0.25s
Fundus Fluorescein angiogram in PDR
While there is no substitute for binocular indirect ophthalmoscopy of the retina, wide-angle imaging enable visualisation and documentation of peripheral pathology that may occasionally go unnoticed, especially in children.
Needle Penetration
Persistent Primary Hyperplastic Vitreous
Macular off RD with large retinal tear
Giant Retinal Tear (GRT)
Peripheral Lattice
Argon laser treated Retinopathy of Prematurity
Retinoblastoma
Acute Retinal Necrosis (ARN) with Optomap®
Ultra-Widefield Retinal Imaging:

- Does it have a role in Clinical Practice?
- Independent of which system we use
Juxtafoveal Telangiectasia
Sickle cell
Asteroid Hyalosis
Non-ischaemic CRVO with CMO Optos® wide-angle FFA
Ischaemic CRVO with CME Optos® wide-angle FFA
Ischaemic CRVO with CME Optos® wide-angle FFA
The advent of Wide-Field Imaging and hence improved means of identifying retinal non-perfusion and penumbra have made TRP a reality.
PDR Response (2,500 burns)

Clinical Outcomes: Inter-grader agreement was substantial (kappa=0.76)

TRP at 12 weeks:
1. Regression of NV comparable to PRP
2. Reduction of ACRT
3. No visual loss
4. Improved Visual Fields

TRP:
- 60% partial regression
- 10% complete regression
- 30% no change

MT-PRP:
- 50% partial regression
- 20% complete regression
- 20% no change

SI-PRP:
- 70% partial regression
- 20% complete regression
- 10% worse

No comparable differences of clinical effects between groups

Optomap® and Children

Advantages for children

– High resolution centre and periphery
– Non-contact
– Can be non-mydriatic
– Rapid acquisition times
– Central positioning not too critical

Disadvantages

– Need moderate co-operation
– Old enough to position head on mount (like S/L)
– Noise can be off-putting
Wide-field Fundus Autofluorescence: Clinical Applications

- Early Diagnosis
- Phenotyping
- Monitoring
- Prognostic Markers
Retinitis Pigmentosa

- Bone spicules
- Narrow vessels
- Optic nerve waxy pallor
- Macular oedema

Atrophy of the mid-peripheral RPE
Retinitis Pigmentosa
X-Linked
Serpiginous Choroiditis

- FAF shows the RPE status better than FFA
- Can predict the final extent of RPE damage
FAF after PRP for diabetic retinopathy

FAF Images 1 month post-laser: Optos WF-FAF
**Retinal Pigment Epithelial Changes on Wide-Field Fundus Autofluorescence and Swept-Source Optical Coherence Tomography Imaging After Successful Retinal Detachment Surgery**

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**Purpose:**
To analyse retinal pigment epithelium (RPE) and neuroretinal (NR) changes on Wide-Field Fundus Autofluorescence (WF-FAF) and Swept-Source Optical Coherence Tomography (SS-OCT) imaging after successful rhegmatogenous retinal detachment (RRD) surgery.

**Methods:**
Retrospective, non-interventional study. We analysed the images of 24 eyes (23 patients) who underwent RRD surgery. All patients were post-operatively imaged using wide-field colour and WF-FAF (200Txi™, Optos plc, Dunfermline, Scotland, UK) and 1,050nm SS-OCT (Atlantis Deep Range Imaging OCT1®, Topcon Inc, Japan). All images were analysed by three independent observers.

**Results:**
The mean age of the study patients was 57.21±13.78 years old. The macula was progressively OFF in 14 eyes and ON in 11. The surgical procedures were: Pars plana vitrectomy (PPV) plus endolaser and intraocular injection of gas in 46.8% (n=11); PPV plus cryotherapy in 33.3% (n=8) and cryobipule surgery in 20.83% (n=5). The post-operative visual acuity (VA) improved in 100% of the patients. However, in two of them the VA was subsequently reduced due to the development of an epiretinal membrane (ERM) and macular oedema (MO). The reported post-operative symptoms included metamorphopsia, central blurred vision and diplopia. We found an abnormal autofluorescence pattern in 83.71% of the macula OFF detachments and in 37.5% of the macula ON detachments. Macula OFF detachments were associated with abnormalities in the outer retina on SS-OCT in 84.61%, and 27.27% in macula ON detachments.

**Conclusion:**
Even though the current success rate in RRD surgery is high, some cases with successful surgical anatomic outcome do not respond with an associated improvement in vision.

Our study shows that the combined use of WF-FAF and SS-OCT could be useful to explain the variation in functional results after anatomically successful RRD surgery. WF-FAF can show variation in the status of the RPE in and outside the posterior pole that may not be clinically observable. WF-FAF and SS-OCT can be powerful diagnostic devices to have a better understanding of the variation in functional response to surgery. Further studies to also look at prognostic markers of functional success are now required.
Preop VA: CF
Postop VA: 6/24
WF-FAF Children

easy and fast to take the images
X-Linked Retinoschisis
Management of Retinal Detachment in Coats’ Disease with Drainage of Subretinal Fluid, Bevacizumab and Laser

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Fig 1. Coats’ Disease Staging

<table>
<thead>
<tr>
<th>Stage</th>
<th>Clinical Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Retinal telangiectasia only</td>
</tr>
<tr>
<td>2</td>
<td>Telangiectasia and exudation</td>
</tr>
<tr>
<td>-A</td>
<td>Extraretinal exudation</td>
</tr>
<tr>
<td>-B</td>
<td>Foveal exudation</td>
</tr>
<tr>
<td>3</td>
<td>Exudative retinal detachment</td>
</tr>
<tr>
<td>-A</td>
<td>Subretinal retinal detachment</td>
</tr>
<tr>
<td>-B</td>
<td>Extraretinal</td>
</tr>
<tr>
<td>-A1</td>
<td>Foveal</td>
</tr>
<tr>
<td>-B</td>
<td>Total retinal detachment</td>
</tr>
<tr>
<td>-A2</td>
<td>Total retinal detachment and glaucoma</td>
</tr>
<tr>
<td>4</td>
<td>Total retinal detachment and glaucoma</td>
</tr>
<tr>
<td>5</td>
<td>Advanced end-stage disease</td>
</tr>
</tbody>
</table>

Introduction:

Management of retinal detachment in Coats’ disease is challenging and often unsatisfactory. Coats’ disease has been classified into 5 stages (Fig 1). Stages 1 and 2 can usually be managed successfully with retinal laser photoacoagulation or cryotherapy.

Management of Stage 3 disease varies and has included sclerotomy and drainage of sub-retinal fluid, bevacizumab or ranibizumab, and vitreoscopy with gas or liquid long-term sub-retinal fluid.

The successful use of bevacizumab in Coats’ disease has previously been reported but not, to our knowledge, in combination with drainage of sub-retinal fluid.

Despite treatment, stage 3 often progresses to stage 4 and 5. This can result in a blind painful eye which may require removal—a situation which has psychological and facial developmental consequences in a child.

Purpose:

To present a series of paediatric patients with exudative vitreous retinal detachment secondary to Coats’ Disease not amenable to laser photoacoagulation or cryotherapy of the telangiectatic retinal blood vessels.

Methods:

Retrospective case note review of 5 consecutive cases.

All eyes underwent surgical drainage of sub-retinal fluid in one or more quadrants and intra-retinal injection of Bevacizumab (Fig 2).

Indirect Argon laser photoacoagulation was subsequently carried out to all vascular retinal abnormalities on attached retina guided by wide-field Retcam fundus fluorescence angiography (Fig 4).

Treatment was carried out over several sessions as the resolution of the sub-retinal fluid allowed.

Results:

All patients were male, aged 4-11 with stage 3 disease at treatment onset.

All patients required only one initial episode of drainage of sub-retinal fluid. 1-2 injections of Bevacizumab and 1-3 sessions of laser photoacoagulation were performed.

All patients showed resolution of the retina with resolution of the sub-retinal fluid (Fig 5).

All eyes showed stable inactive disease at final follow up (0-34 months) with no eyes progressing to end-stage disease.

Conclusions:

We present a novel therapeutic approach which allows for the successful treatment of advanced cases of exudative retinal detachment in Coats’ Disease without the need of vitreous surgery. The aim of the treatment is to prevent the development of its sequelae, pitheosis bells and therefore a blind and painful eye in a child.

References:

All wide-field imaging systems induce distortion anterior to the equator as every camera and scanner produces a 2D representation (Optomap®) of a sphere (retina)

To enable anatomically-correct measurements on Optomap® images we must know where each pixel on the (Opto)map is on the sphere (retina) while maintaining spatial relationships (angles)
Optomap® Stereographic Projection:

Enables anatomically-correct measurements

- 7.4 mm
- 4.0 mm
New software to assess areas of retinal non-perfusion on Optomap® Wide-Field Fundus Fluorescein Angiography: “Manchester Grid”
Wide-Field Fundus Fluorescein Angiography in Diabetic Macular Oedema: a Study of Midperipheral and Peripheral Retinal Perfusion

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Background:

Even though advanced technologies and new treatments have been very helpful in improving the knowledge of Diabetic Retinopathy (DR), some aspects of the pathophysiology are still not known.

The ischemia in DR has been postulated to have an important role in the development of Diabetic Macular Oedema (DMO).

Retinal hypoxia/ischemia is the basic stimulus leading to the marked 'upregulation' and 'increase' of vascular endothelial growth factor (VEGF), which have been identified as playing a role in the pathogenesis of DMO.

Anti-VEGF drugs are currently used in the treatment of DMO and have demonstrated to be effective even in cases not responding to laser photoagulation. Therefore, it makes sense to hypothesize that retinal ischemia and DMO may be associated, but conventional retinal imaging of ischemia makes it challenging to study this association.

Purpose:

To develop new software to assess the location and quantify the area of retinal non-perfusion (RNP) and its relationship with Central Macular Thickness (CMT) in patients with DMO on wide-field fundus fluorescein angiography (WF-FFA).

Methods:

Retrospective review of 76 Optomap® WF-FFA images of patients with DMO.

A grid was superimposed over the WF-FFA image (each cell being one disc area of 1.77mm²).

The image was divided into 3 zones:
1. Posterior Pole (PP): within an ellipse centered on the fovea, passing through a point one disc diameter from the nasal edge of the optic disc (OD) and including the vascular arcades. See figure 4.
2. Mid-peripheral (MP): outside the PP but within a circle centered on the OD and passing along the posterior edge of the vortex vein ampulla on the green-free image, see figure 1A.
3. Peripheral (P): anterior to the MP zone, see figure 4.

Two independent graders classified each cell within zones 2 & 3 as:
1. (>50% perfused)
2. (=50% perfused)
3. (<50% perfused)
4. (poor image quality) or
5. (blockage by cystoid maculopathy)

In case of disagreement of >10 cells scored as 2 or 3 in zone 2 the image was rescoring by the two graders together. The agreement between the two graders was calculated using the Bland-Altman method, see figure 2. The same method was used to show the limits of agreement between OCT thickness and the grading, see figure 3. Correlation coefficients were calculated to assess the relationship between CMT and area of RNP.

Results:

Coefficient of agreement for the MP was 21 cells. Thirteen images were regraded due to disagreements between the 2 graders.

Mean CMT was 290µm (range 199-406µm)

Average of RNP areas in MP was 4.17% (range 0-25%). Correlation coefficient with CMT was 0.349, p=0.019.

Average of RNP areas in P was 2.01% (range 0-29%). There was no correlation with CMT and peripheral RNP areas.

Conclusions:

This new software package allows for a more objective and accurate quantification of the area and location of retinal non-perfusion in the mid and peripheral on Optomap® WF-FFA.

Retinal non-perfusion associated with DMO is mainly located in the mid-periphery. We found a weak correlation between CMT and mid-peripheral retinal non-perfusion. The main limitation could be the lack of samples with thicker CMT.

Further studies using this new software are required to ascertain the area and role of retinal non-perfusion in DMO and other ischemic retinal diseases.
The Manchester Practice in 2014:

Most retinopathies undergo Wide-field imaging

We carry out Topcon® or wide-angle Optos® AF imaging prior to repeating laser

Most CHILDREN with retinopathies undergo wide-angle imaging: colour, GF and AF

Once you try Wide-field Imaging you may not want to go back!
With thanks to:

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