ULTRA-WIDE IMAGING

True colour ultra-widefield imaging is now a reality in practice, writes independent optometrist Craig McArthur

While many of you were spending your evenings watching flames flicker in your fireplace, glass of wine in hand and comfortably guarded from the heavy snow and icy temperatures that hit the UK this month, I dragged myself away from such exploits to write about my experience using a pre-production prototype of the newly-released Zeiss Clarus 500 HD Ultra-Widefield Fundus Imaging system.

The aim was to prove whether the product's sales strapline of *Widefield Without Compromise* is justified. This article aims to offer an insight into my week with the innovative camera, offering an overview of its features and clinical benefits.

Delivery of the camera sparked an interesting conversation about the evolution of retinal imaging and a walk-down memory lane for my colleague Peter Ivins, who joined the General Optical Council (GOC) register in July 1980. Like the delivery of a new car encouraging a chat about 'my first car' (a red Citroen Saxo with red seat belts) and then every car owned since, the delivery of the camera had Peter regaling me with every fundus camera he had purchased over his 38-year career. From loading polaroid into the back of his first fundus camera in the 80's, to his first digital retinal camera in the 90's and now to our first ultra-widefield camera.

FIGURE 1 The first retinal camera from 1926 (image courtesy of Zeiss)

WHERE IT ALL STARTED: THE EVOLUTION OF FUNDUSCOPY

French surgeon Jean Méry first witnessed the living retina in 1704, albeit only the red reflex of a cat.[1] For the next 140 years, scientists such as Czech physiologist Jan Evangelista Purkinje, English ophthalmologist William Cumming and German physiologist Ernst Wilhelm Ritter von Brücke tried and ultimately failed to successfully visualise the retina. They did nevertheless improve our understanding of the optics and techniques involved.[2–4] Charles Babbage was the first to construct an instrument for looking into the eye, in 1847. However, this early design was not entirely successful nor widely used.[5,6] Hermann von Helmholtz is regarded as the father of ophthalmoscopy with the invention of his Augenspiegel (eye mirror) in 1851, by 1854 known by its familiar name—the ophthalmoscope (eye mirror).[7–9] Since then, optometrists and ophthalmologists have been looking for new and improved ways to visualise and, more importantly, document the structures of the eye and the features of ocular diseases.

BRIEF HISTORY OF RETINAL IMAGING

The first human fundus photograph is accredited to Jackman and Webster, who published their technique along with a reproduction of a fundus image in two photography periodicals in 1886.[10,11] However, it was the Carl Zeiss Company who introduced the first commercially available fundus camera rather surprisingly in 1926.[12] This early camera, shown in figure 1, provided a 20° fundus image, with the field of view (FoV) later expanded to 30°. Most modern digital retinal cameras will offer a FoV between 30° to 45°. A view of more than 50° is considered widefield imaging, and more recent developments have given rise to ultra-widefield imaging with views of between 100° to 200°. A comparison between the FoVs offered by different retinal imaging techniques is shown in table 1.

OPTOMETRY'S ACCEPTANCE OF TECHNOLOGY: THE PACE QUICKENS

Despite the technology being in existence since the 1920's, it has taken over 80 years for retinal photography to become the norm in optometric practice. As many of you might know, as of

TABLE 1 Comparison of retinal examination techniques to field of view

Examination technique	Field of view (FoV)
Direct ophthalmoscopy	≈ 5° –10°
PanOptic™ ophthalmoscope	≈ 25°
Indirect ophthalmoscopy	≈ 37°
Traditional fundus photography	30° –45°
Zeiss Clarus 500	200° wide by 200° tall

FIGURE 2 **The Zeiss Clarus 500**

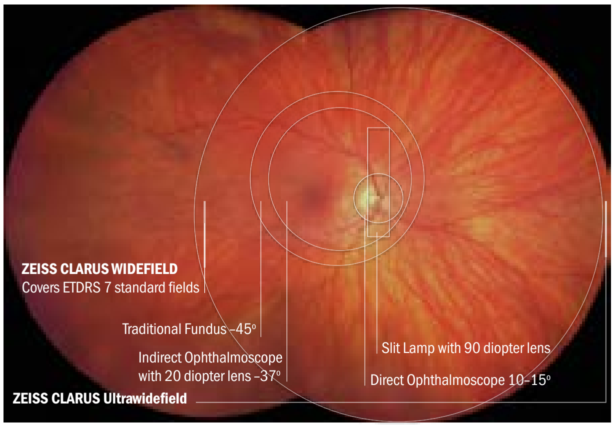

FIGURE 3 **A visual representation of the field of view offered by examination techniques**

1st April 2006, the NHS (General Ophthalmic Services) (Scotland) Regulations were established.[13] Everyone in Scotland became eligible for a fully-funded, comprehensive NHS primary eye examination with a monetary incentive for practices to take a retinal photograph in patients aged over 60. Our colleagues at Optometry Scotland went one better in late 2007, announcing a grant of up to £10,000 per practice to help purchase a retinal camera within an approved specification level. Rather than trying to infuriate my colleagues elsewhere in the UK with this information, I am hoping to make the point that this intervention massively expedited the uptake and use of retinal cameras in Scotland, with the rest of the UK quickly following suit in the widespread use of digital retinal photography. Fundus photography has become ubiquitous and is now even achievable with your smart phone.[14]

OCT UPTAKE MUCH QUICKER THAN RETINAL PHOTOGRAPHY

Optical coherence tomography (OCT) uptake fared slightly better with Zeiss releasing the first commercial time-domain OCT (the OCT1000) in 1996, the second generation OCT2000 in 2000 and the Stratus OCT in 2003.[15] The Zeiss Cirrus HD-OCT and many others marked the first commercially available spectral domain high-speed, high-resolution OCTs on the market in 2006.[16] OCT technology has not only advanced at an incredible rate since its introduction just over 20 years ago, but has also become widely used and the standard of care in ophthalmology and optometry in a comparatively short period of time.[17–23]

ULTRA-WIDEFIELD IMAGING: THE NEW NORMAL?

Having myself qualified as an optometrist in August 2008, I am almost embarrassed to admit that I have never practised without a digital retinal camera nor for that matter an OCT. As the rate of our acceptance of new technologies as a profession continues to rapidly gather pace, will the latest crop of newly qualified optometrists joining the GOC register in 2018 reminisce about a time before high-definition, true colour ultra-widefield digital retinal photography? And will this technique fast become the expected norm in retinal imaging?

INTRODUCING THE ZEISS CLARUS 500

The Zeiss Clarus 500 is a non-contact, non-mydriatic, high-resolution imaging device for true colour ultra-widefield *in vivo* imaging of the human retina and external structures of the eye. The Clarus 500, shown in figure 2, represents a significant breakthrough in diagnosing and monitoring retinal disease compared with existing fundus camera and scanning laser ophthalmoscope (SLO) systems due to its combined ultra-widefield and true colour imaging.

The ophthalmic camera is intended to capture, display, measure, annotate and store images to aid in the diagnosis and monitoring of diseases and disorders occurring in the retina, ocular surface and visible adnexa. It allows the clinician to capture highly detailed, 12megapixel, 200° images with a resolution of 7microns in undilated pupils as small as 2.5mm. An image illustrating the FoV and detail can be seen in figure 3.

The Clarus 500 offers a variety of imaging modalities, including true colour reflectance imaging, infrared reflectance (IR), and fundus autofluorescence (FAF) with green or blue excitation (FAF-G and FAF-B) for stereo, widefield, ultra-widefield, and montage FoVs. Fluorescein angiography and indocyanine green angiography capabilities are in the pipeline for a future release, which may be of interest to hospital-based practitioners.

BROAD LINE FUNDUS IMAGING: HOW DOES IT WORK?

The Clarus 500 produces true colour images via sequential illumination by broad-spectrum red, green, and blue light emitting diodes (LEDs), whereby a broad rectangle of light sweeps across the retina and is detected using a monochromatic camera. This technique is referred to as broad line fundus imaging (BLFI). Red, green, and blue LEDs sequentially illuminate the retina to generate natural-looking, true colour fundus images, like those seen via direct observation of the retina in direct or indirect ophthalmoscopy. →

TABLE 2 **Clarus 500: Field of view (FoV) options**

Technique	Description
Widefield	A single image captures a FoV of 133° wide by 133° high
Ultra-widefield	Two images stitched together into a montage with a FoV of 200° wide by 133°high
Auto montage	A 4-scan montage using preset fixation targets. FoV 200° wide by 200° high
Montaged images	Up to six widefield images montaged in an operator-selected configuration

ULTRA-WIDE IMAGING

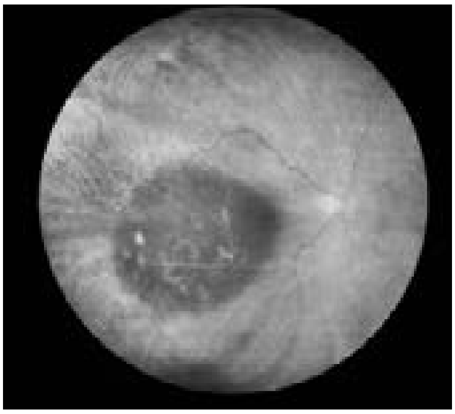

FIGURE 4 Red channel separation showing a choroidal naevus

FIGURE 5 Green channel separation revealing retinal haemorrhaging in diabetic retinopathy

FIGURE 6 Blue channel separation showing detail in the retinal nerve fibre layer

By illuminating only a narrow strip of the retina at a time, the illumination stays out of the viewing path, keeping haze and fluorescence of the anterior segment out of the retinal image and allowing a clear view of much more of the retina than the annular-ring illumination used in traditional fundus cameras. The design allows a single exposure to image 133° of the retina, previously covered by the 7-fields protocol in the early treatment of diabetic retinopathy study (ETDRS). Multiple image captures (between 2–6) can then be montaged to achieve high-definition, true colour, ultra-widefield retinal photographs 200° wide by 200° high (or greater), with a 7μm resolution. The FoV options are listed in table 2.

RGB CHANNEL SEPARATION: GO SHALLOW OR GO DEEP?

True colour images can be separated into red, green and blue channel images to enhance the visual contrast of details in certain layers of the retina. This can further aid in the diagnosis, monitoring and documenting of various ocular pathologies. The wavelength of light used in each RGB channel is outlined in table 3.

The red channel exploits light between 585–640nm, which bypasses the retinal vasculature and the retinal pigment epithelium and is particularly useful in visualising choroidal lesions (see figure 4). The green channel uses light between 500–585nm, which exhibits strong absorption by haemoglobin in the retinal vasculature, making this channel particularly useful in visualising retinal haemorrhaging in diabetes and retinal holes; an example is shown in figure 5. The blue channel comprises of light between 435–500nm, which is very effective in visualising and detecting pathologies in the anterior retina, such as an epiretinal membrane or retinal nerve fibre layer defect as shown in figure 6.

FUNDUS AUTOFLUORESCENCE (FAF) WITH GREEN OR BLUE EXCITATION (FAF-G AND FAF-B)

Fundus autofluorescence (FAF) imaging is a non-invasive technique which provides useful clinical information on retinal metabolism and retinal health by detecting naturally or pathologically occurring fluorophores. FAF illustrates the integrity and metabolic alterations of the retinal pigment epithelium (RPE), important factors in the pathogenesis of several retinal disorders and macular conditions. The Clarus 500 offers fundus autofluorescence with green excitation (FAF-G) during which the eye is illuminated with light at a wavelength that stimulates the natural fluorescence of lipofuscin. This is useful in visualising RPE health and the changes seen in non-exudative maculopathy, as shown in figure 7. The Clarus 500 also offers fundus autofluorescence with blue excitation (FAF-B), useful for measuring and tracking geographic atrophy as shown in figure 8.

TABLE 3 Wavelengths of light used in BLFI and IR imaging

Light source	Wavelength
Red LED	585-640nm
Green LED	500-585nm
Blue LED	435-500nm
IR laser diode	785nm

INFRARED REFLECTANCE (IR) AND EXTERNAL IMAGING

Infrared reflectance (IR) provides the unique optical property of increased penetration through tissue, providing improved visualisation of choroidal structures. IR can also be combined with the external eye imaging capabilities of the Clarus 500 to visualise meibomian glands as shown in figure 9—a useful addition to any dry eye clinic without a meibographer.

Full colour external eye imaging is also a useful addition to a practice devoid of a photo slit lamp biomicroscope or corneal topographer with anterior eye imaging capabilities. The ability to image the anterior eye, shown in figure 10, is useful in monitoring conditions of the anterior segment and can be very useful for patient education.

SOFTWARE, AESTHETICS AND BACKUP

The Clarus 500 is aesthetically impressive. The camera is connected to the all-in-one touchscreen PC on a swinging boom stand. The operator controls the instrument and software using the instrument joystick, touchscreen, wireless keyboard and touchpad. The software offers a simple and efficient workflow, further improved by use of the Zeiss Forum platform.

This Zeiss Forum system allows a patient's information to be added to one computer and then sent to all connected devices, such as our HFA3 visual field analyser, Visucam 200 retinal camera, Cirrus 5000 HD-OCT and now the Clarus 500, rather than information having to be individually added to each machine. Images and reports from each system—or any other DICOM or non-DICOM third-party devices, such as my Topcon and CSO photo slit lamps and Oculus Corneal Topographer—can be stored and viewed in one place, within one programme, allowing remote viewing from any number of computers or iPads. Not only does this significantly improve the efficiency of

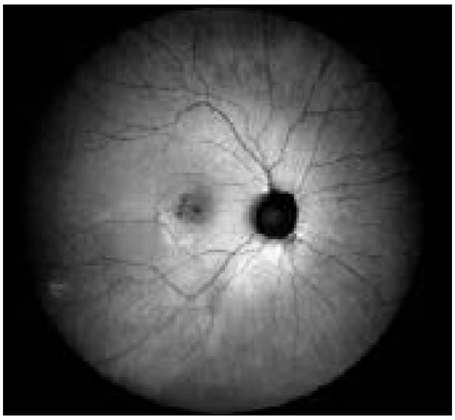

FIGURE 7 **FAF Green in dry AMD**

FIGURE 8 **FAF Blue in geographic atrophy in dry AMD**

FIGURE 9 **IR imaging of meibomian glands**

our patient journey, but also simplifies our backup protocol for disaster recovery. Proper and correct data management is an often overlooked aspect of purchasing a new piece of equipment, and should be carefully planned and considered. The Zeiss Forum system, in conjunction with some investment in a backup server and cloud storage solution, can help solve this problem.

CAPTURING IMAGES COULD NOT BE EASIER

The operator sees a live view of the retina via the use of infrared light, making alignment of the camera very simple. The camera arcs around a central anchoring, similar to a slit lamp, to allow for optimal imaging. Capturing images is quite straightforward thanks to accurate auto-focussing. The live capture screen is intuitive to any existing user of a retinal camera or OCT. This live view, the patient position on a chin rest, use of either internal or external patient fixation and the use of a joystick will be familiar to most users of traditional digital fundus cameras. This familiarity extends to our patients, who are used to chin rests of this nature with most visual field analysers, slit lamp, autorefractors, OCTs, etc. using similar setups. This improves patient comfort and cooperation.

The cumulation of these factors significantly accelerates the learning curve for the operator. This process relies less on the cooperation from the patient to align themselves to the camera as with the Optos, and results in far fewer repeat exposures due to misalignments and lash/lid artefacts. Our three optometrists, three of our dispensing opticians and our clinical assistants were able to capture impressive images first time without any training.

ULTRA-WIDEFIELD DIGITAL RETINAL PHOTOGRAPHY: WHAT ARE MY OPTIONS?

Wide-field imaging is not a new concept with manual and automatic multi-image montaging in traditional and digital fundus cameras;[24] the 'Equator Plus' Pomerantzeff film camera, from the 1970's;[25–29] the Panoret-1000 camera, in the early 2000's;[30] various versions of the RetCam system, from the late 1990's onwards;[31] use of the Heidelberg HRA or Spectralis in conjunction with an Ocular Staurenghi 230 SLO Retina Lens, introduced in the mid-2000's;[32] various incarnations of the Optos system, originally launched in 2000, which represented the first truly ultra-widefield imaging system;[33] the Eidon confocal scanner in late 2014, which was the first true colour retinal imaging system,[34] and now the Zeiss Clarus 500, in 2018, which represents the first true colour ultra-widefield imaging system. So, why should I consider the Clarus 500?

HOW DOES THE CLARUS 500 COMPARE WITH THE OTHERS?

The Equator Plus and Panoret-1000 are no longer commercially available. The RetCam III is a contact-based coaxial illumination system, which obtains a 130° FoV. This wide-angle camera is used predominantly by paediatric ophthalmologists in examining neonates and infants with retinopathy of prematurity,[31] and is not suited to a busy optometric practice. The Heidelberg HRA or Spectralis, in conjunction with an Ocular Staurenghi 230 SLO Retina Lens, whist excellent, is considered by this review to be less suitable to a busy optometric practice, as the skill level and techniques involved are likely to limit its use to the optometrist alone, rather than auxiliary staff, unlike other options available.

Various multi-image montaging protocols using 5-standard, 7-standard and 9-standard fields have been studied in an attempt to acquire images of the retinal periphery in a systematic manner in diabetic retinopathy and longitudinal studies of ocular complications of AIDS to capture peripheral cytomegalovirus retinitis.[35] However, multi-image montages produced by traditional fundus cameras are time consuming, offer a limited FoV and are prone to artefacts.

The Clarus 500 is most likely to be compared with the

FIGURE 10 **Colour imaging of the anterior segment**

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TABLE 4 Clarus 500: Field of view options

System	Fundus illumination	Camera type	Field of view	Available to buy?	Pro's	Con's
'Equator Plus' Pomerantzeff camera	Transscleral	Contact	148°	No	■ First wide-field system	■ Not commercially available
Ret-Cam	Transpupillary	Contact	130°	Yes	■ Portable ■ Great on neonates and children	■ Poor imaging through lens opacities
Heidelberg HRA / Spectralsis with Staurenghi Lens	Transpupillary	Contact and non-contact options	150°	Yes	■ High resolution images ■ Patient comfort as imaging less bright ■ Video capabilities	■ Contact poses a risk of corneal insult ■ Limited to use by optometrist
Multi-image montaging with traditional fundus camera	Transpupillary	Non-contact	Variable	Yes	■ Software modification of current system ■ Easy-to-learn technique ■ Auxiliary members of team capable of capturing images	■ Requires dilation due to multiple flashes ■ Artefacts ■ Time consuming
Eidon confocal scanner	Transpupillary	Non-contact	60° (H) x 55° (V) captured in a single exposure	Yes	■ Fully automated or manual modes	■ Lower field of view
Optos	Transpupillary	Non-contact	200° with once exposure	Yes	■ Single image capture to achieve 200° image ■ Easy to learn ■ Fast image capture	■ Pseudo-colour rendering ■ Requires cooperative patient ■ Artefacts (lids, lashes, lens and exposure)
Clarus 500	Transpupillary	Non-contact	133° (H) x 133° (V) in single exposure 200° (H) x 133° with two exposures	Yes	■ Easy-to-learn technique ■ Auxiliary members of team capable of capturing images ■ Fewer recaptures due to live IR view ■ True colour images ■ Anterior eye imaging including meibomian glands	■ Two image captures required to achieve 200°

Eidon confocal scanner and the various Optos systems. The various options for widefield imaging are summarised in table 4.

ULTRA-WIDEFIELD TRUE COLOUR HIGH RESOLUTION IMAGING: WHY IS THIS IMPORTANT?

True colour imaging is designed to replicate the appearance of the retina as seen by direct observation with our own eyes whilst using traditional ophthalmoscopy techniques. This allows the practitioner to document the appearance of the retina more accurately then previous methods used in retinal imaging.

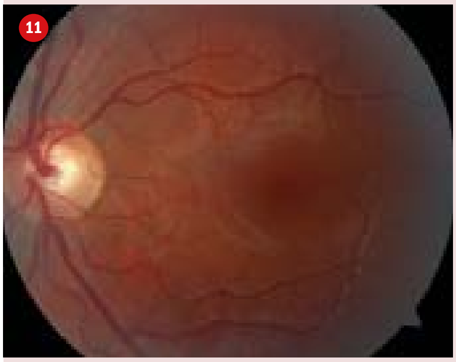
Conventional fundus cameras capture colour retinal images which are over-exposed in the red channel, meaning minutiae such as small retinal haemorrhages and intra-retinal microaneurysms (IRMA) in diabetics may be missed and detail of the optic nerve head lost. Ultra-widefield SLO imaging systems, such as the Optos, offer pseudo-colour images which do not provide an accurate representation of retinal anatomy as seen during direct observation, and may result in misdiagnosis due to colour artefacts. The Eidon True Colour Confocal Scanner was the first system to combine the advantages of SLO with the fidelity of true colour imaging, and as such overcame those limitations encountered by traditional fundus photography and the Optos. However, the Eidon is limited to a 60° FoV, meaning pathology in the periphery may be overlooked.

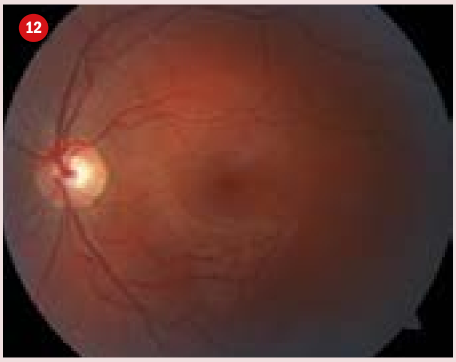
The Clarus 500 offers, for the first time, the combined advantage of ultra-widefield and true colour imaging thus providing the clinician with an accurate representation of the anatomy of the eye and all the detailed information required for an accurate diagnosis. This is vitally important in the differential diagnosis of the plethora of peripheral retinal disorders such as choroidal naevi, choroidal melanoma, diabetic retinopathy, and vitreo-retinal anomalies, as well as disorders of the posterior pole and optic nerve head. The high-fidelity images produced by the Clarus 500 are incredibly detailed, offering an optical resolution of 7μm and surpassing the Eidon, which features a 15μm resolution, and the Optos, which offers 14–20μm resolution depending on the model. In short, the Eidon achieves true colour imaging, the Optos achieves true ultra-widefield imaging, and the Clarus 500 achieves both, with an improved resolution.

When compared with the Optos, the Clarus 500 is arguably easier to use as capturing the image relies on the operator rather than the patient for correct alignment. It is also less prone to lid and lash artefacts. The true colour images of a higher resolution offered by the Clarus 500 are also an improvement on the Optos. However, the Clarus 500 requires two image exposures to produce a 200°, whereas the Optos only requires a single exposure.

CASE STUDY 1: A YOUNG, HEALTHY PATIENT

We will spend a significant portion of our time examining healthy retinae, often in an undilated state in young healthy individuals. With that in mind, figures 11–15 show the difference between 30°, 45°, 5-field montage images in traditional fundus photography compared with the 133° and 200° by 200° images offered by the Clarus 500 in a healthy, young asymptomatic 24-year-old male. All photos are taken with the eye undilated. The high-fidelity, true colour images from the Clarus 500 are far superior in detail and diagnostically much more useful than those offered by the traditional fundus camera.





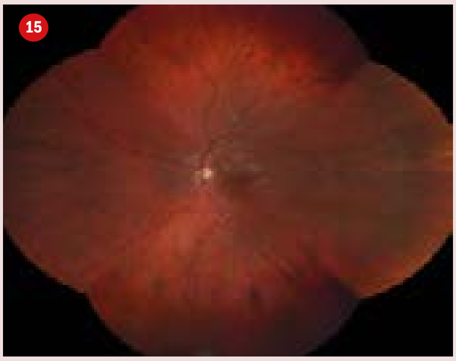


FIGURE 11 30° photo of healthy eye

FIGURE 12 45° photo of healthy eye

FIGURE 13 5-field multi-image montage of healthy eye

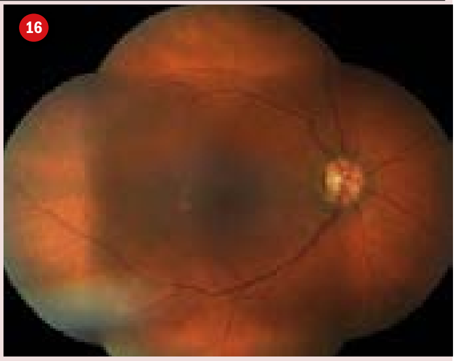
FIGURE 14 Clarus single exposure 133° image

FIGURE 15 Clarus 200° x 200° multi-image montage

CASE STUDY 2: CHOROIDITIS

Age: 63
Sex: Female
History and symptoms:
Patient asymptomatic
Past ocular history:
Mild bilateral nuclear sclerosis
General health:
Non-insulin-dependent diabetes, hypertension, hypocholesteraemia
Medications:
Metformin, Ramapril, Atenolol, Simvastatin
Refraction and visual acuity:
R: +0.25 / +0.25 X 100 6/6 Add +2.25 (N5)
L: plano / +1.00 x 60 6/6 Add +2.25 (N5)
Pupil Reactions:
Normal
IOPs:
R: 14mmHg
L: 14mmHg
Visual field analysis:
Normal

Figure 16 shows photographs taken of this patient using a Zeiss Visucam 200 and the automated 5-field multi-image montage with the eye undilated. This image shows a small patch of hypo-pigmentation temporal to the fovea. Figure 17 shows the same patient, again in an undilated state, with the internal fixation set to the superior temporal position. The 133° single exposure image taken with the Clarus 500 reveals and documents an old choroiditis scar in the peripheral retina. This lesion, whilst visible during dilated indirect ophthalmoscopy, was out with the viewing capabilities of our traditional retinal camera and, as such, we have previously been unable to document the scar for monitoring. The Clarus 500 was not only able to photograph the lesion, but did so in an undilated 63-year-old female.



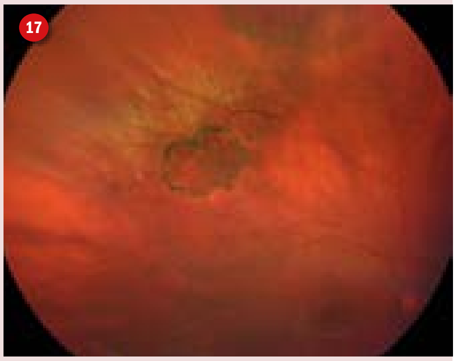


FIGURE 16 Visucam 200 5-field montage

FIGURE 17 Clarus 133° image of an old choroiditis

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CASE STUDY 3: DIABETIC RETINOPATHY

Age: 30
Sex: Male
History and symptoms:
Patient asymptomatic
Past ocular history:
Previous background diabetic retinopathy
General health:
Insulin-dependant diabetes
Medications:
Insulin, NovoMix 30
Refraction and visual acuity:
R: –2.25 / +0.25 x 90; 6/7.5 (N5)
L: –2.25 / +0.25 X 80; 6/6 (N5)
Pupil Reactions:
Normal
IOPs:
R: 12mmHg
L: 12mmHg
Visual field analysis:
Normal

Figure 18 shows an ultra-widefield 200° by 133° image which documents the extent of this young man's diabetic retinopathy. Again, this image was captured before he was dilated. The ability to document retinal haemorrhages beyond the central 45° or standard 7-field ETDRS montage with the Clarus 500 will allow for much improved monitoring of his disease progression, potentially a game changer in diabetic screening.

FIGURE 18 Clarus 500 200° (w) by 133° (h) image of diabetic retinopathy

CASE STUDY 4: RETINOSCHISIS

Age: 41
Sex: Male
History and symptoms:
Patient asymptomatic
Past ocular history:
Nil
General health:
In good health
Medications:
Nil
Refraction and visual acuity:
R: –3.25 / +2.25 x 120; 6/6 (N5)
L: –2.75 / +1.25 X 95; 6/6 (N5)
Pupil Reactions:
Normal
IOPs:
R: 16mmHg
L: 17mmHg
Visual field analysis:
Small defect detected in left eye

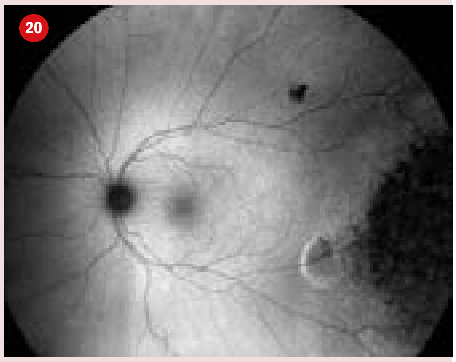

Figure 19 shows a 133° image depicting a left temporal retinoschisis. Figure 20, a 133° FAF-G image, enhances the disruption of the retinal architecture induced by retinoschisis.

FIGURE 19 Clarus 500 133° image of retinoschisis

FIGURE 20 Clarus 500 133° FAF-G image of retinoschisis

WHY DO I NEED ULTRA-WIDEFIELD IMAGING? THE CLINICAL ARGUMENTS

A significant and continual increase in life expectancy in recent times has resulted in a demographic shift towards an elderly population in the UK and in many other developed countries.[36] This shift coupled with increased rates in myopia[37] and an increase in the number of lens extraction procedures, either as a result of cataract[38,39] or for refractive purposes, and has been linked with an increased risk of retinal detachment.[40–46]

In the case of retinal detachment, the earlier an ophthalmologist sees the patient the greater the chance the macula is still attached, and the better the prognosis after surgical intervention.[47] As the gatekeepers to vision care, optometrists have a crucial role in the early detection of retinal conditions such as retinal detachment. Ultra-widefield retinal (UWF) imaging is a useful adjunct to the gold standard of indirect ophthalmoscopy for investigation and documentation of retinal conditions.[48] The Clarus 500 may further improve the early detection of subtle retinal tears, holes and postoperative scarring due to the true colour images and improved resolution, and therefore improve our ability to appropriately refer to our vitreo-retinal colleagues in a speedy manner.

We are also seeing a significant increase in the incidence and prevalence of diabetes[49] and, as a result, diabetic retinopathy.[50] Visualisation of the peripheral retina using UWF imaging has been shown to improve diagnosis and classification of diabetic retinopathy.[51] Furthermore, accurate quantification of retinal haemorrhage and/or microaneurysm using UWF images may provide a more accurate representation of diabetic retinopathy disease activity and potentially greater accuracy in predicting diabetic retinopathy progression.[52] Again, the true colour and higher resolution images produced by the Clarus 500 will further improve our ability to screen for and monitor diabetic retinopathy.

WHY DO I NEED ULTRA-WIDEFIELD IMAGING? THE BUSINESS ARGUMENTS

There is an inherent '*keeping up with the Joneses*' effect in diagnostic technology in optometric practice. This has been accelerated by television, social media and online advertising campaigns by many of the industry's big players. With retinal photography becoming an expected norm, and OCT not far behind, ultra-widefield retinal imaging seems a natural progression for any practice hoping to '*keep ahead of the Joneses*' in this highly competitive market.

The service not only improves our clinical offering, but potentially offers a strong marketing advantage in the acquisition and retention of patients. Furthermore, the Clarus 500 offers an additional revenue stream if implemented successfully in a fee-based practice. In a market saturated with the sale of commodities, such as spectacles and contact lenses, and eye care being handed away free to encourage such sales by many practices, additional revenue generated by the appropriate remuneration for our skill, expertise and investment in innovative diagnostic technology like that of the Clarus 500 will be most welcome, particularly to the independent market.

The Clarus 500 offers peace of mind in those 5pm on a Saturday evening flashing lights and floaters patients we all see on occasion. Detailed and accurate photographic documentation can be a valuable asset for medico-legal purposes.[53] More important now than ever in the current landscape left in the wake of the tragic case of Vinnie Barker and the subsequent legal proceedings for optometrist Honey Rose. Appropriate use of such technology will hopefully benefit patients and optometrists alike.

CONCLUSION

It is fitting that Carl Zeiss, who brought us the first retinal camera in 1926 and first OCT in 1996, should be the first to bring us a true colour ultra-widefield retinal camera in 2018. The ability to document the retina in a 200° by 200° 7µm true colour image, combined with FAF-G, FAF-B, IR and anterior colour imaging capabilities means the Clarus 500 is an exciting addition to the clinical armamentarium of any practice. I liked it so much I bought one.

Declaration of interest: this article was supported by Zeiss.

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