Contemporary imaging of retinopathy of prematurity

Retinal imaging in infants with retinopathy of prematurity (ROP) has become increasingly important for diagnosis, documentation, and treatment guidance. In this review, the current methods of retinal imaging available to infants with ROP are outlined, highlighting the advantages and disadvantages of each method, with special attention to non-contact ultra-widefield imaging, which the authors have recently popularised.

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Key points

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1. Retinal imaging is playing an increasingly important role in the management of infants with retinopathy of prematurity (ROP).
2. There is a wide range of retinal imaging devices capable of providing documentation and meaningful clinical data that can help manage infants with ROP.
3. Each imaging modality has its own advantages and disadvantages.

Retinopathy of prematurity (ROP) is a preventable cause of blindness that is routinely screened for in the UK for all premature infants with a gestational age of less than 32 weeks and/or a birth weight of less than 1,501g.[1] The current gold standard method for screening for ROP requires the use of a binocular indirect ophthalmoscope together with a condensing lens (**FIGURE 1**). Retinal drawings are used to document findings and to monitor the disease. This method of screening is variably difficult and subjective. The correct diagnoses can be missed, either when the ophthalmologist is inexperienced or when the infant is too sick to allow adequate time for the examination.

Retinal imaging provides an objective documentation of the disease state at a specific time point and reduces medico-legal risk. Additionally, having the ability to compare images taken pre-treatment with those taken post-treatment helps evaluate success so that further management can be planned.

Available methods of retinal imaging for ROP infants

A comparison of the different imaging modalities used in infants with ROP is shown in **TABLE 1**.

NIDEK handheld fundus camera

The NIDEK NM200D camera (**FIGURE 2**) is a handheld camera that captures a 30-degree field of view of the retina. It has been used for the detection of plus disease (where the blood vessels of the retina become enlarged, indicating a worsening of the condition) in infants with ROP.[2] The low quality of images generated and the narrow field of view have prevented its widespread use.

FIGURE 1 Indirect ophthalmoscopy, the current gold standard method for screening for ROP.

FIGURE 2 The NIDEK NM200D handheld fundus camera.

Video indirect ophthalmoscopy

Retinal images are captured from video recordings from a camera mounted inside a binocular indirect ophthalmoscope, therefore no additional imaging procedure is necessary. However, these images are of low quality and have a narrow field of view (**FIGURE 3**), although the field of view can be enlarged through mosaicing techniques.[3] It is the most cost effective method of obtaining retinal images in infants.

Contact widefield imaging

The most popular imaging modality is

Imaging modality	Fundal field of view	Setting for use	Staffing requirement	Advantages	Disadvantages
NIDEK camera	30 degrees	• Special care baby unit • Outpatient department • Theatre	• Ophthalmologist	• Non-contact based • Portable	• Low resolution images • Narrow field of view • Only colour imaging available • Unable to image out to the edge of the retina (ora serrata)
Video indirect ophthal-moscopy	53 degrees/69 degrees (28D condensing lens) 46 degrees/60 degrees (20D condensing lens)	• Special care baby unit • Outpatient department • Theatre	• Ophthalmologist • Nursing staff to monitor vital signs	• Portable • Cost effective • Able to image out to the ora serrata through scleral indentation	• Contact based • Narrow field of view • Low resolution images • Only colour imaging available
RetCam widefield camera	130 degrees	• Special care baby unit • Outpatient department • Theatre	• Ophthalmologist • Nursing staff to monitor vital signs	• Portable • Wide fundal field of view • Fast image acquisition • Colour and fluorescein angiographic imaging available	• Contact based • Sedation or general anaesthesia essential for high quality angiograms • Unable to image out to ora serrata • Cost
Optos ultra-widefield camera	200 degrees	• Outpatient department	• Ophthalmologist • Nursing staff to monitor vital signs • Ophthalmic photographer	• Non-contact based • Fast image acquisition • High resolution images • Wide fundal field of view • Colour and fluorescein angiographic imaging available • No sedation or general anaesthesia required to obtain images	• Non-portable • Unable to image out to ora serrata • Cost • Ophthalmic photographer needed for image capture

TABLE 1 Comparison of modalities used for imaging of premature infants with ROP.

RetCam (Clarity Medical Systems, Pleasanton, USA), a handheld contact lens-based widefield-imaging system that allows colour fundus photography and fluorescein angiography (**FIGURES 4 and 5**). To acquire an image, the pupil is dilated with cyclopentolate 0.5% and phenylephrine 2.5%. Topical anaesthesia and a coupling agent are applied onto the cornea. A lens is chosen depending on the desired field of view (up to 130 degrees).

RetCam has the advantage of being portable, can be operated by non-physicians, and can produce high quality images in well-sedated and anaesthetised infants.[4] Although this imaging system is generally safe to use in premature infants, it can induce retinal haemorrhages impairing the diagnosis of plus disease, a vital sign that necessitates the need for treatment.[5,6] Infant distress is an inherent problem of any contact-based system such as RetCam.

Non-contact ultra-widefield imaging

Since August 2012, the Oxford Eye Hospital has been using the Optos Optomap (Optos, Dunfermline, UK) to image premature infants with ROP. The

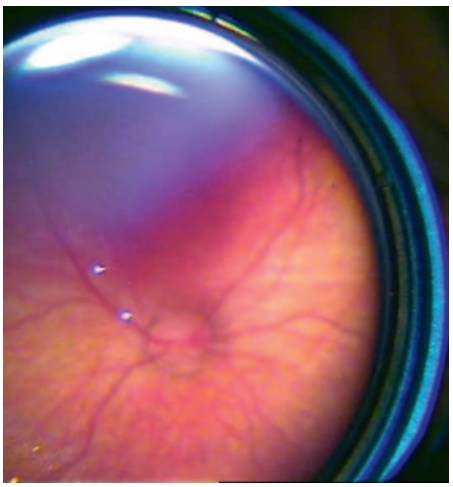


FIGURE 3 Image from a video indirect ophthalmoscope recording.

FIGURE 4 The RetCam Shuttle widefield imaging device

Optos Optomap (**FIGURE 6**) is an ultra-widefield imaging device that uses a scanning laser ophthalmoscope to capture retinal images with up to a 200-degree field of view.[7] This ophthalmic imaging technology uses laser light instead of a bright flash of white light to illuminate the retina. The authors have previously demonstrated that this device is capable of obtaining high quality colour and fluorescein angiographic images in infants with ROP (**FIGURES 7 and 8**).[8-10]

To capture images with the Optos Optomap, topical anaesthesia and mydriasis (dilation of the pupil) are required. A paediatric eyelid speculum is inserted before the infant is held up to the imaging device in the 'flying baby' position, with one hand supporting the body and the contralateral hand supporting the head (**FIGURE 9**). The photographer then captures images once the pupil is aligned. Hydration of the eyes with 0.9% normal saline is essential to optimise image clarity. No sedation or general anaesthesia is necessary.

The presence of neonatal staff to monitor vital signs (heart rate, blood pressure, oxygen saturations) during the imaging process is advocated. The fast image acquisition time of the Optos Optomap limits the amount of time an infant is held up to the device: a maximum of one minute per eye for colour imaging and a maximum of 2-3 minutes per eye for fluorescein angiographic imaging is all that is required. The infant can be wrapped in a blanket while being held up to the imaging device. All infants that have been imaged in Oxford have tolerated the procedure well with none experiencing any adverse cardiorespiratory effects. Further studies specifically evaluating the safety aspect of this technique are underway in the department.

The authors found several advantages of the Optos Optomap that they feel make it ideal for imaging premature infants with ROP. Firstly, the ultra-wide retinal field of view has the advantage of enabling pathology in the posterior pole and the periphery to be captured in a single image, removing the need to capture multiple images and hence reducing the time needed to image infants. There is less potential for inducing infant distress because the device is non-contact, image acquisition is very fast, and laser illumination is not as bright as incandescent light. Lastly, the higher

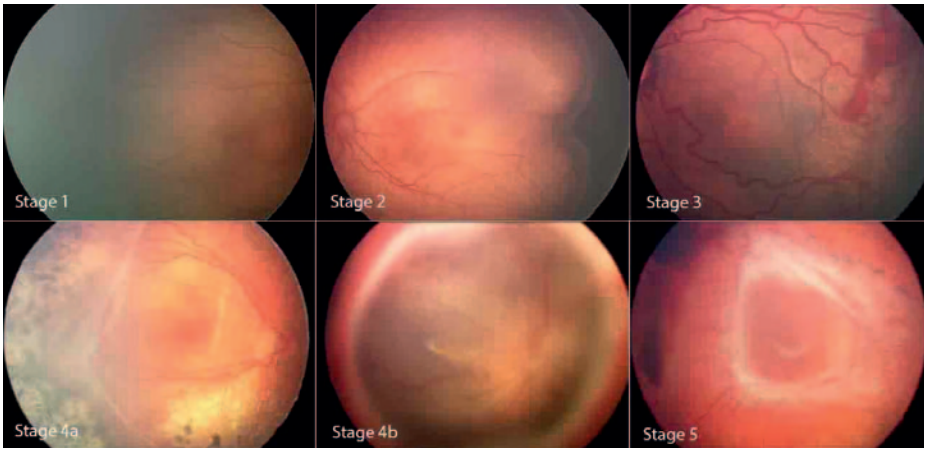
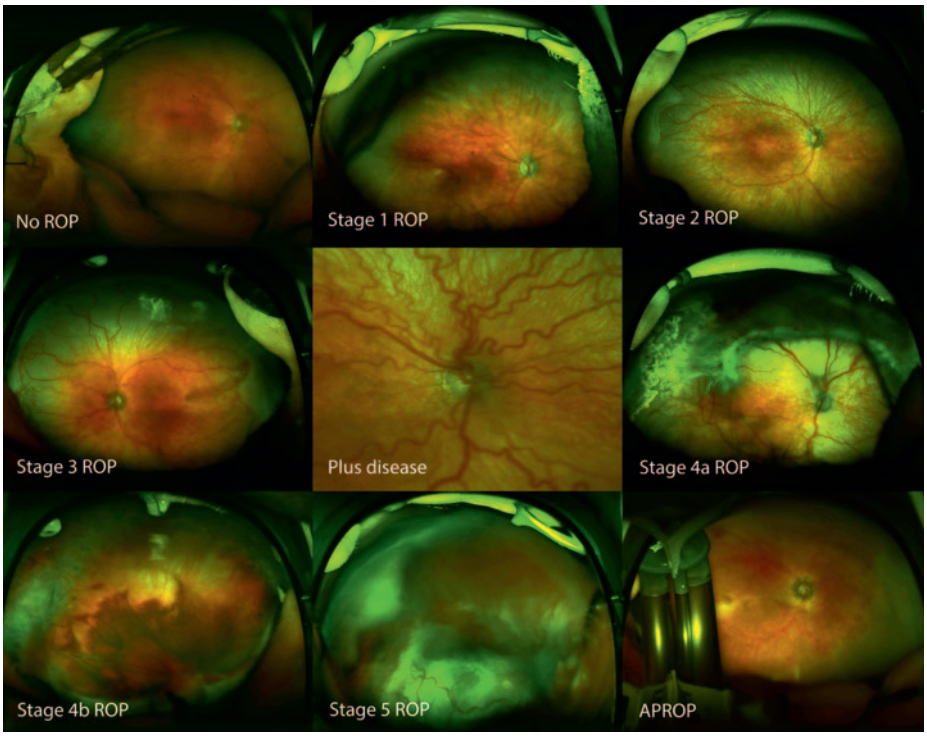


FIGURE 5 RetCam widefield colour fundus images. ROP is classified in five stages, ranging from mild (stage 1) to severe (stage 5).

FIGURE 6 (left) The Optos Optomap ultra-widefield imaging device.

FIGURE 7 (below) Optos Optomap ultra-widefield colour fundus images showing the various stages of ROP disease. Key: APROP = aggressive posterior ROP.



resolution of images obtained can increase diagnostic accuracy.

At Oxford, imaging of infants has been restricted to the outpatients department because the device is large and non-portable. Neonatal staff transfer infants to the department, with or without incubators as driven by clinical need. There has been recent collaboration with the manufacturers to allow the Optomap device to be moved easily so that it can be used in the neonatal unit.

Potential future imaging modalities

The size or cost of the current imaging modalities restricts their widespread use. To overcome these limitations, studies are now being conducted to determine whether mobile phone-based retinal imaging is feasible.[11] With the potential advantages of portability, high data storage capacity and the wireless connectivity of mobile phones, it is not inconceivable that a mobile phone-based retinal camera could soon play an important role in infants with ROP.

Conclusions

Retinal imaging is able to provide documentation and clinically meaningful data that are able to help improve management of infants with ROP. Numerous studies have been published that describe different imaging modalities for ROP infants, with each having its own advantages and disadvantages. With increasingly advanced retinal imaging modalities, there is no doubt that imaging will play an increasingly integral part in the evaluation of infants with ROP.

Declaration of interest

The authors have no financial relationship with any of the equipment discussed in this article.

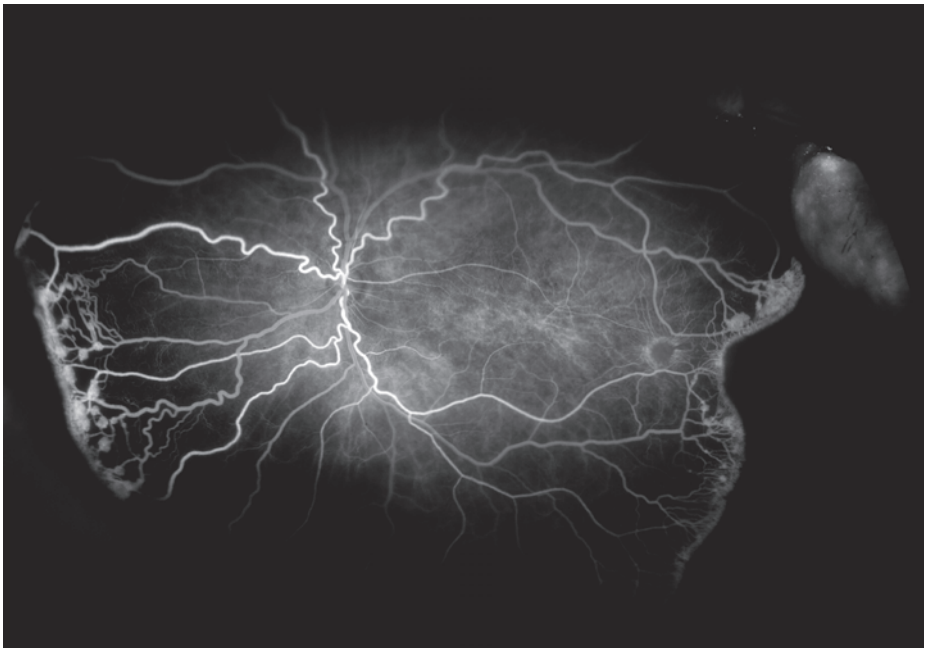


FIGURE 8 Optos Optomap ultra-widefield fluorescein angiographic image.

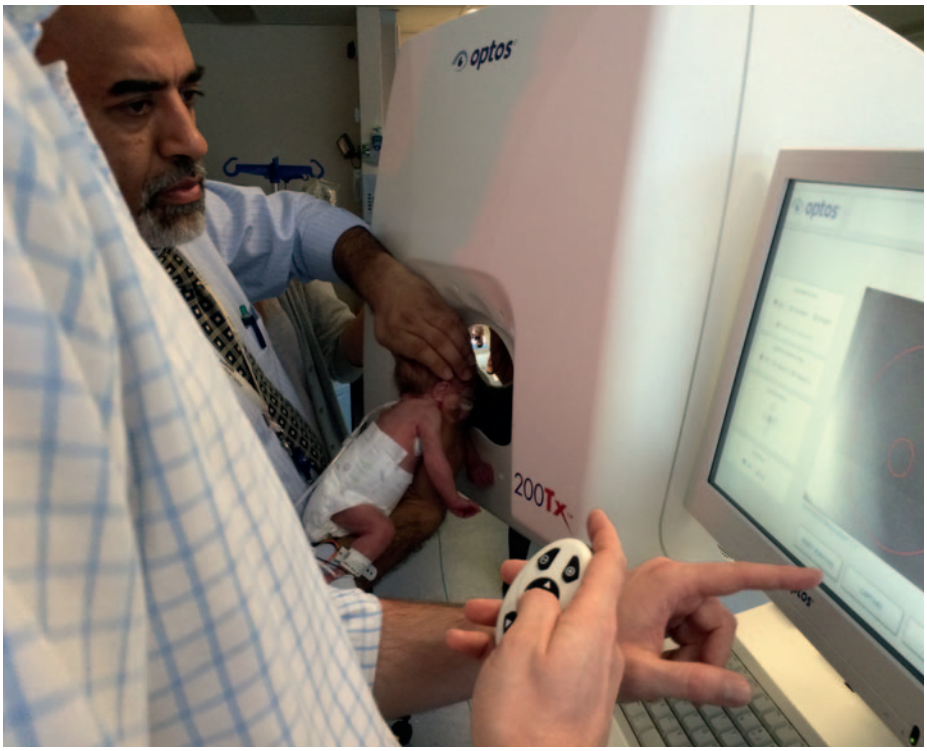


FIGURE 9 Capturing images with the Optos Optomap: the infant is held up to the imaging device in the 'flying baby' position.

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