Common retinal signs
An overview

Optometrists and ophthalmologists are uniquely placed to directly visualise through the ocular media various inflammatory, vascular and other pathological processes as they occur inside the eye.

The increasing use of small, powerful, hand-held indirect lenses for slit lamp biomicroscopy over the past couple of decades represents a major leap forward in our ability to examine the fundus in much greater detail, and with more clarity than was ever possible with the direct ophthalmoscope. Along with the ability to see these retinal changes comes the need to have some knowledge about their origin, pathology and clinical significance.

This article outlines some frequently observed ophthalmoscopic findings in optometric practice. It is not intended to be an exhaustive discussion of retinal conditions. Commonly encountered retinal abnormalities may be broadly grouped into the following categories for the purposes of explanation: haemorrhages, exudates, cotton wool spots, blood vessel abnormalities and pigmentation.

It is important to remember that the normal retina is transparent. The retinal arterioles and venules run in the nerve fibre layer of the retina and are thus the only part of the retina readily visible on fundoscopy. The reddish orange glow of the fundus is generated by reflection from the choroids, which is a rich network of blood vessels sandwiched between the retina and the sclera. When the retina is thin, as in myopes or the elderly, the underlying choroidal vessels are more prominent.

Haemorrhages

Blood in the posterior segment implies a breach in the continuity of the wall of healthy or diseased blood vessels. It may cause visual symptoms depending upon which part of the fundus is involved. The haemorrhages may involve the vitreous, the retina and frequently both. The need for further investigation and the urgency of referral will be guided by taking into account the patient's age and history.

Vitreous haemorrhage

Bleeding into the vitreous rarely goes unnoticed and patients usually seek attention early. The amount of blood present will determine what both the (previously normal) patient and examiner can see. A dense, diffuse bleed will prevent light from entering the eye causing sudden alarming loss of vision, and no view of the fundus on examination. A slow trickle of blood on the other hand is more likely to give rise initially to the symptom of floaters while affording a reasonably useful view of the retina to the examiner.

The pattern of spread of blood in the vitreous is also guided by whether the vitreous is still attached to the retina or detached. In the former case, the blood may remain confined to a narrow compartment between the retinal surface and the posterior face of the vitreous, a condition called subhyaloid bleeding (**Figure 1**). When the vitreous is detached, i.e. collapsed, it is no longer in contact with most of the retinal surface and there is nothing to prevent the blood from oozing into the vitreous cavity and diffusing throughout the posterior segment like a smoke-screen, an appearance to which the name 'intra-gel haemorrhage' is sometimes given. The same pattern would be expected if the vitreous was absent, such as after a vitrectomy.

The most common causes of vitreous haemorrhage are bleeding new vessels. The origin of these is discussed later. Most frequent causes of new vessels are diabetes mellitus and previous retinal vein occlusion. The patient should be asked whether he/she is a known diabetic and the fellow eye examined for evidence of diabetic retinopathy. Patients with a previous vein occlusion may have a history of sub-normal vision in the affected eye prior to the vitreous haemorrhage, and are frequently middle-aged to elderly hypertensives.

Posterior vitreous detachment is another cause of vitreous haemorrhage. The vitreous is normally attached to the inner surface of the retina. This attachment is particularly strong around the optic disc, around retinal blood vessels and over the most anterior part of the retina, an area of the vitreous called the vitreous base. Due to mostly unknown reasons, at some stage in an individual's life (usually after middle age) the vitreous degenerates, implodes on itself and collapses. In the process, it pulls on the retina which, in turn, is stimulated into generating the only response it can – namely transmitting light and hence the frequent but not invariable symptom of flashing lights (photopsia) associated with a collapsing vitreous. If this pull on the retina is sufficiently strong, it can occasionally avulse and tear a blood vessel on the retinal surface, or indeed tear the retina itself. The blood thus liberated diffuses throughout the now liquefied vitreous and reduces vision. A history of photopsia preceding the visual loss may provide a valuable clue to the diagnosis.

Less common causes of vitreous haemorrhage include intraocular inflammation, breakthrough bleeding from a macular disciform haemorrhage or macroaneurysm of a retinal artery, bleeding disorders, malignant melanoma, trauma, recent posterior segment surgery and sub-arachnoid haemorrhage. Vitreous haemorrhage in a child must be viewed with suspicion, as it may be a manifestation of non-accidental trauma.

Regardless of the cause of the vitreous haemorrhage, all such cases should be referred to an ophthalmologist without delay. In the absence of a useful fundus view, the key question is whether the retina is detached or not. B-scan ultrasound is undertaken to rule out a detachment and this may occasionally show the flap of a retinal tear, even when the retina is still attached. Urgent surgical intervention is then usually indicated.

Most cases of vitreous haemorrhage do tend to resolve gradually, although this may be much more protracted if the patient is on anti-coagulants, or if the vessels continue to bleed profusely. As the haemoglobin in the blood is absorbed the clots acquire a whitish yellow appearance, the so-called 'chicken-fat' stage, and tend to sink towards the lower quadrants of the eye. Unresolved and untreated, vitreous haemorrhage can cause scarring and membrane formation on the retinal surface, as well as haemolytic glaucoma due to anterior diffusion of the red blood cells, which then clog the drainage angle.

Retinal haemorrhages

The discovery of retinal haemorrhages may be a chance finding at a routine eye examination or more frequently, the visual consequence of the haemorrhages may be the reason why the patient seeks attention.

Figure 1
Sub-hyaloid haemorrhage
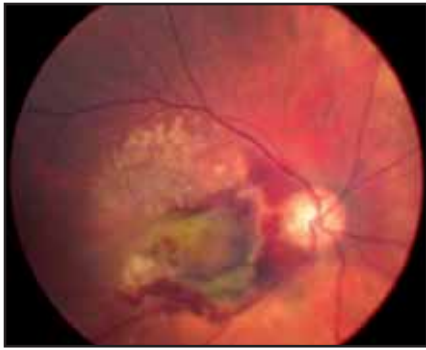
>> *Figure 2*
Macular haemorrhage related to AMD

>> *Figure 3*
Circinate exudates in diabetes

>> *Figure 4*
Cotton wool spots in radiation retinopathy

Even though many conditions can cause retinal bleeding, the actual haemorrhage itself is not immediately treatable in the vast majority of cases. Therefore a semi-urgent referral to the ophthalmologist is usually adequate, unless the patient is a known diabetic, in which case urgent referral is justified. Since the examiner can only view the retina from the front, it can be difficult to judge the depth or level of the haemorrhage within the retina. However, by using some indirect clues, a reasonably accurate estimate can be made.

The nerve fibre layer is one of the inner most (superficial) layers of the retina and consists of millions of tightly packed bundles of nerve fibres running parallel to each other. Any blood escaping from vessels in this layer will not be able to spread concentrically like an inkblot. Instead, it will insinuate in between the nerve fibres assuming an elongated shape as it tries to spread along the nerve bundles. Such spindle, or 'flame-shaped haemorrhages' as they are called, are thus indicative of damaged capillaries within the superficial retina and are most frequently associated with systemic hypertension. These flame haemorrhages are bright red since there is no layer of overlying cells to diminish their redness. They seldom cause symptoms, unless overlying the macula, and may disappear. Blood from deeper retinal capillaries, however, although equally red, appears slightly darker to the observer since it is masked to some extent by the overlying nuclear and plexiform retinal layers. Furthermore, in the deeper layers of the retina, there are no tightly woven nerve fibres to channel the blood in a flame-shaped pattern and so it is free to spread in a round, blotchy fashion. These deeper, slightly darker blotch haemorrhages are more frequently seen in diabetes and vein occlusions, and may be indicative of ischaemic damage to the capillaries. Any bleeding occurring deep into the retinal pigment epithelium (RPE) will be significantly masked by the pigment in the RPE and will thus appear darker still.

These haemorrhages most frequently arise from the choroidal vessels which can occasionally gain access to the sub-RPE space in the macular area as part of the spectrum of age-related macular degeneration (AMD) (**Figure 2**).

Exudates

'Hard' or 'waxy' exudates are visible on fundoscopy as yellowish deposits in the retina. Their presence implies leaking retinal capillaries. Normally there are tight junctions between the cells lining the retinal blood vessels, collectively constituting the inner blood retina barrier which normally prevents leakage of fluid into the spaces of the retina. Blood comprises a red, cellular portion but also a clear portion called the plasma. Any condition which damages the blood retina barrier will allow the plasma to seep through the gaps between the lining cells and into the retina. Along with the plasma, lipid-containing neuronal breakdown products also seep out and impart the yellow colour to the hard exudates. Diabetes is the most common disorder responsible for such a vascular leakage. The weakened capillary walls develop out-pouchings in their walls called microaneurysms, which may also leak.

Exudates very frequently arrange themselves in a circular pattern in diabetes, and often there is a cluster of leaking microaneurysms in the middle of such a ring of exudates. This arrangement is called 'circinate exudates' (**Figure 3**). As with most other conditions, exudates affect vision only when they encroach on the macula, and hence the need for regular retinal screening of diabetic subjects so that any exudates approaching the macula may be treated. The macula contains the highest density of photoreceptors and that is why it provides us with the sharpest vision – just like a digital camera with a higher number of pixels gives a much sharper image. Exudative fluid seeping through the tightly packed retinal layers pushes them apart disturbing the macular architecture and thus resulting in loss of acuity.

Severe systemic hypertension can also cause hard exudates to form but here instead of forming circinates, the exudates usually align themselves in a radiating pattern from the macula, the 'macular star'. This may also be seen in optic neuritis and papilloedema.

The Early Treatment of Diabetic Retinopathy Study (ETDRS) recommends laser treatment for exudates within a third of a disc diameter of the fovea. However, for the purposes of screening and optometric referral, any exudates within the temporal vascular arcades should be considered clinically significant and referred to an ophthalmologist.

Smaller circinates usually disappear following laser treatment, which stops the leakage and allows the lipid deposits to be gradually removed by macrophage cells. Larger aggregations of hard exudates, however, seldom resolve altogether and tend to persist despite laser treatment.

Cotton wool spots

These were earlier also known as soft exudates, which is a misnomer since the term exudate implies vascular leakage. Cotton wool spots appear as a result of capillary shut down, not leakage, and their presence implies retinal ischaemia. The underlying cause is almost invariably a systemic one such as diabetes, hypertension, HIV infection or a connective tissue disease.

Cotton wool spots appear in the retinal nerve fibre layer, which consists of sheets of axons of the retinal ganglion cells on their way to the optic disc to form the optic nerve. These nerve fibres are nourished by the retinal capillaries, blockage of which causes a localised area of infarction. The usual flow of cell organelles and axoplasm is interrupted when it reaches the infarcted patch, and it is here that the axoplasmic debris starts accumulating. Clinically, this is visible as a cotton wool spot (**Figure 4**), the size of which is determined by the number of axons involved in a given infarct.

Depending on the extent of ischaemia, any number can be seen although they are mostly found around the posterior pole, perhaps because this is where the retinal nerve fibre layer is thickest. In diabetes cotton wool spots indicate advanced background or pre-proliferative stages of retinopathy. Cotton wool spots are usually

transient and rarely remain visible for more than a few months.

It is important to realise that cotton wool spots, exudates and retinal haemorrhages frequently co-exist since they may appear as a result of the same vascular disorders, the most common being diabetes and hypertension.

Blood vessel abnormalities

On gross examination with the ophthalmoscope or hand-held lens, the major blood vessels of the normal retina are readily visible against the transparent retina. The arterioles and venules are located in the nerve fibre layer. The capillaries are located both in the nerve fibre layer as well as the inner nuclear layer of the retina.

Hypertension and its sequelae mostly affect the capillaries of the nerve fibre layer whereas it is the inner nuclear layer capillaries which are damaged in diabetes. Hence, the often observed difference in shape of haemorrhages in these conditions, as described earlier.

Vascular tortuousity

Tortuous blood vessels may be a completely normal finding, especially if seen to be bilaterally symmetrical in an otherwise healthy person in the absence of any other retinal abnormality. Serial retinal photography over a period of years will show the unchanging nature of these vessel changes. In pathological states, veins are more prone to become dilated and tortuous since they have a much thinner wall, lacking the muscular coating of the arterioles. Conditions which impede drainage of blood out of the retina back towards the heart will cause blood to dam up in the veins, which will then start to become engorged and generally enlarged. Increased venous pressure outside the eyeball will cause this to happen, as would thickening of the blood itself in hyperviscosity syndromes like polycythaemia. Tortuous and dilated veins are seen in advanced background diabetic retinopathy and also in papilloedema, due to pressure on the central retinal vein as it exits the eyeball at the lamina cribrosa. A similar appearance is seen in impending occlusion of the central retinal vein, the differentiating feature being less pronounced disc swelling and absence of similar changes in the fellow eye in vein occlusion.

Vascular pulsation

Pulsation can be seen in retinal vessels only when the pressure in the vessel equals the intraocular pressure (IOP). The pressure in the central retinal vein is normally equal to the IOP, i.e. on average 15mmHg. The pressure in the artery entering the eye has been estimated to be within 65-70mmHg. Since blood flow into the eye is directed against a much lower gradient (i.e. the IOP), there is a steady stream of blood flow into the eye via the artery and no pulsation is seen. Every heartbeat does, however, induce a minute increase in the volume of blood in the ocular circulation. This causes a very slight momentary rise in IOP, which is sufficient to collapse the central retinal vein at the optic disc. Clinically, this is seen as the venous pulsation and it is a normal finding. Arterial pulsation, on the other hand, is always pathological, since it can only be produced if the IOP is high enough to collapse the central retinal artery as it enters the eyeball at a pressure of around 65-70mmHg. This occurs in severe glaucoma and can also be observed by manually pressing on the eyeball to raise the IOP, such as during examination of the retina using a fundus contact lens when the lens can be progressively pressed onto the eyeball until the central retinal artery is seen to pulsate. A hyperdynamic systemic circulation raises the pulse pressure and may also cause an arterial pulse to appear. This is seen in aortic regurgitation.

New vessels

New (abnormal) vessels in the retina may arise from the vessels of the retina itself or may invade the outer part of the retina having originated from the underlying choroid. The former is seen as a response to widespread retinal ischaemia. When large parts of the retina lose their blood supply, the retinal cells become hypoxic. Clinically, this is most often seen in advanced diabetic retinopathy or an ischaemic type of retinal vein occlusion. Both these conditions cause widespread capillary shut down. The hypoxic retina is thought to produce an angiogenic factor which stimulates the formation of new vessels. These are initially intraretinal but then appear on the surface of the retina. The optic disc is a site of predilection for these vessels to appear (**Figure 5**).

Predominantly, it is the veins which give rise to new vessels, although rarely arterial new vessels may also be observed. These new vessels lack the muscle coating and tight junctions of normal retinal vessels. In fact, they are little more than fenestrated tubes of endothelial cells. This fragility makes them prone to bleeding, causing pre-retinal and vitreous haemorrhage. Prompt laser treatment to destroy the hypoxic retina reduces the angiogenic factor produced by it and causes the new vessels to regress. This is why the discovery of new vessels in the retina is an indication for urgent referral to an ophthalmologist.

New blood vessels originating in the choroid may also occasionally gain access to the retina. Although many conditions can cause this, the most common clinical situation is AMD. The initial event is a hole formation in Bruch's membrane, which is the layer of tissue separating the choroid from the RPE. Capillaries growing

Florid disc new vessels

Subretinal neovascular membrane

from the choroid gain access through this hole to a space beneath the RPE. From here they can penetrate between the RPE and the sensory retina. This collection of capillaries derived from the choroid is called a sub-retinal neovascular membrane (SRNVM).

Although any part of the retina can be involved, the macula seems to be a common site. Distortion of vision occurs when this membrane leaks clear fluid thereby soaking the retinal photoreceptors. At this stage, the SRNVM may be either invisible or may have a greenish hue (**Figure 6**). It can also bleed leading to a sudden drastic drop in central vision. Fluorescein angiography is essential to detect the actual location of the SRNVM in relation to the fovea so that laser treatment or photodynamic therapy (PDT) may be considered.

Abnormal pigmentation

The degree of redness of a normal fundus is determined by the amount of melanin in the RPE cells. Increasing age, as well as myopia, decrease the amount of melanin and as a result, the underlying choriocapillaris is more prominent. This melanin may be absent altogether in albinism so that the choroid and sclera are clearly visible. The choroid also contains melanin, although it is more brownish as compared to the jet black melanin of the RPE. Proliferation of the RPE leads to the development of visible blackish clumps in the retina. These may be focal (localised) or diffuse (widespread). Furthermore, they

can be present at birth or acquired later in life, although in the latter case they take weeks or months to develop rather than hours or days. Pigment proliferation in the retina therefore seldom represents an acute event and thus in the absence of symptoms, should not constitute a cause for urgent referral.

Congenital hypertrophy of the RPE (CHRPE) is a common lesion, which is only seen if specifically looked for since it is asymptomatic in the vast majority of individuals. As the name suggests, it is present at birth, regardless of the fact that it may only be first noticed when a 45-year old visits their optometrist for reading spectacles. The lesion itself is a well circumscribed, circular or oval pigmented patch (**Figure 7**) which is mostly solitary. The degree of pigmentation is seen to vary if these lesions are observed over the course of years, although the actual size does not usually change. Lacunae of depigmentation are frequently seen within the pigmented area, and gradually merge and enlarge.

Localised RPE proliferation may also be seen after inflammatory episodes, such as chorioretinitis. Laser treatment also stimulates RPE proliferation, and this is said to be one of the mechanisms by which focal laser treatment works, i.e. encourages absorption of localised retinal oedema by causing the RPE to locally proliferate. Widespread (diffuse) RPE proliferation is most often seen in retinitis pigmentosa and following pan-retinal laser treatment.

Not all pigmented fundus lesions are derived from the RPE however. Choroidal naevi consist of clusters of pigment containing cells called naevus cells, which are plumper than normal choroidal pigmented cells but have no malignant features. These naevi are benign common lesions and are said to be present in up to 30% of fair-skinned individuals. Just like CHRPE, choroidal naevi are mostly present at birth, although may remain undetected since their pigmentation and size only start to increase around puberty. Detection is almost invariably at a routine eye examination. They may be distinguished from CHRPE by their relatively less well defined margins and their greyish rather than blackish colour (**Figure 8**). Furthermore, retinal blood vessels seen to pass over a naevus are a clue to its deeper, choroidal location.

With the passage of time, degenerative changes, such as drusen, may appear in the retina overlying the naevus. Malignant

Figure 7
Congenital hypertrophy of RPE

Figure 8
Choroidal naevus

transformation of a choroidal naevus is a rare event but it must be remembered that most malignant melanomas of the choroid have around their edges histological changes resembling naevi, and are therefore preceded by naevi. The most important risk factor for malignant change is the size of the naevus, a lesion greater than 5mm wide and 2mm thick being regarded as suspicious. For practical purposes, any naevus larger than 3mm in size, or situated in close proximity to the optic disc or macula, should be referred to an ophthalmologist so that it may be photographed, an ultrasound performed and followed up. The same is true for naevi showing orange pigment on the surface or seen to be unusually elevated.

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