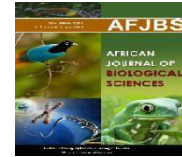




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# Fundus Ophthalmological Examination And Fundus Photography In Children With Type 1 Diabetes Mellitus: an overview

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**Abstract:** Type 1 diabetes mellitus (T1DM) is considered an autoimmune disease in which the function of pancreatic  $\beta$ -cells which secrete insulin is impaired. Diabetic retinopathy (DR) is the most common complication of T1DM. Several authors recommend that clinical ophthalmic examinations as a screening method for DR be started 3–5 years after a diagnosis of T1DM, followed by annual reviews for pediatric patients older than 9 years. On the other hand, another opinion recommends both clinical fundus examination and fundus photography annually for all T1DM patients aged 12 years and older. Fundus photography is the most effective screening method for DR, with high sensitivity and accuracy. In many countries, photographic screening of children with T1DM is recommended to commence at the age of 10 years regardless of the duration of T1DM. Fundus photography and direct ophthalmoscopy must be considered as golden tools for screening DR. Further larger, multi-center studies are recommended to evaluate the accuracy of fundus photography versus direct ophthalmoscopy.

**Keywords:** Diabetes; Mellitus; Fundus; Ophthalmology

### Introduction

Type 1 diabetes mellitus (T1DM) is considered an autoimmune disease in which the function of pancreatic  $\beta$ -cells which secrete insulin is impaired. Diabetic retinopathy (DR) is the most common complication of T1DM. Several authors recommend that clinical ophthalmic examinations as a screening method for DR be started 3–5 years after a diagnosis of T1DM, followed by annual reviews for pediatric patients older than 9 years. On the other hand, another opinion recommends both clinical fundus examination and fundus photography annually for all T1DM patients aged 12 years and older (*Surowiec et al., 2022*). Fundus photography is the most effective screening method for DR, with high sensitivity and accuracy. Screening is often carried out with a 45-degree fundus camera. However, stationary 60-degree cameras can also be used for better coverage of the

fundi. A green filter and monochromatic photography enhance the detection of hemoglobin-containing changes, as compared with colour images (*Yu et al., 2021*). In many countries, photographic screening of children with T1DM is recommended to commence at the age of 10 years regardless of the duration of T1DM. This age was chosen as a compromise as compared to an individual onset of photography at the beginning of puberty, which is when DR usually starts to occur. DR has, however, been reported in prepubertal children. If no DR is detected, imaging should be performed at 2-year intervals and annually after DR is detected or if images are ungradable (*Eszes et al., 2021*).

#### **Diabetic retinopathy: a challenging debate**

Whether patients develop diabetic retinopathy depends on the duration of their diabetes and on the level of glycemic control. The following are the 5 stages in the progression of diabetic retinopathy:

1. Dilation of the retinal venules and formation of retinal capillary microaneurysms.
2. Increased vascular permeability.
3. Vascular occlusion and retinal ischemia.
4. Proliferation of new blood vessels on the surface of the retina.
5. Hemorrhage and contraction of the fibrovascular proliferation and the vitreous (*Robert et al., 2018*).

The patient may not notice a change in visual acuity unless the center of the macula is involved. Macular edema can cause visual loss; therefore, all patients with suspected macular edema must be referred to an ophthalmologist for evaluation and possible laser therapy. Laser therapy is effective in decreasing macular edema and preserving vision but is less effective in restoring lost vision (*Chetan, 2019*). Proliferative retinopathy is characterized by neovascularization, or the development of networks of fragile new vessels that often are seen on the optic disc or along the main vascular arcades. The vessels undergo cycles of proliferation and regression. During proliferation, fibrous adhesions develop between the vessels and the vitreous. Subsequent contraction of the adhesions can result in traction on the retina and retinal detachment. Contraction also tears the new vessels, which hemorrhage into the vitreous (*Iqbal, 2018*).

#### **Monitoring of type 1 diabetes: a global task**

Monitoring of glycemic control includes daily monitoring at home as well as periodic monitoring, which can be achieved by the following methods:

##### **1) Monitoring of blood glucose:**

In most diabetes centers it is recognized that self monitoring of blood glucose (SMBG) is an essential tool in the management of childhood and adolescent diabetes because it helps to monitor immediate and daily levels of control, detects hypoglycemia, assists in the safe management of hyperglycemia and helps to guide insulin adjustments to decrease blood glucose fluctuations (*Desai, 2020*). Each child should have their targets determined with the goal of achieving a value close to normal as possible while avoiding hyperglycemia (*Tauschmann, 2018*).

##### **2) Monitoring of urinary ketones:**

It is good clinical practice to advise urinary ketone (B-hydroxy butyrate) measurement during episodes of uncontrolled hyperglycemia, insulin deficiency 'sick days' and impending ketoacidosis (*Chetan, 2019*).

##### **3) Glycated hemoglobin:**

Glucose attaches itself to the molecule of hemoglobin (Hb) during the life cycle of the circulating red cell, forming glycated hemoglobin (HbA1c), which reflects levels of glycemia over the preceding 4-12 weeks. HbA1c monitoring has been shown to be the most useful measure in evaluating metabolic control and is the only measure for which good data are available in term so fits relationship with later micro vascular complications (*Paschou et al., 2018*).

##### **4) Fructosamine and other glycated products:**

Fructosamine measures the glycation of serum proteins such as albumin and reflects glycemia over, the preceding 3-4 weeks. It is therefore used for the assessment of shorter periods of control than HbA1c (*Santos et al., 2023*).

### **Fundus examination in children: a worldwide concern**

It could be argued that whoever carries out an eye examination should take responsibility for examining the fundus. This poses a dilemma for optometrists in different parts of the world. Optometrists in some countries are not licensed to use mydriatics (e.g., Portugal, Spain, France). In those countries where mydriatics are used (e.g., UK, Holland, USA) not every optometrist dilates the pupil of every patient on every occasion (**Wang, 2023**). In some countries, optometrists are forbidden to examine the retina (e.g., Greece). If mydriasis is not used, then a full view of the fundus cannot be expected and a thorough examination of the ocular fundi in children poses additional difficulties. Mydriatics commonly used are the anti-muscarinics Tropicamide 0.5% or 1% and the sympathomimetic, Phenylephrine 2.5%. Sympathomimetics are contraindicated in premature babies and phenylephrine 10% is contraindicated in children and must never be used in infants as it may cause a cardiovascular hypertensive crisis (**Patel et al., 2019**). Examining the ocular media and fundi of younger children and babies can be much more difficult than examining fully co-operative older children or adults. Babies and infants tend to fixate on the light source of direct ophthalmoscope thus giving a view of the macular but little else. An adequate view of the optic nerve and periphery may not be possible (**Tang et al., 2018**). If a full examination of the ocular fundus of a baby or young child is critically important e.g., suspected pathology then the ophthalmologist may use a sedative e.g., chloral hydrate, or a general anaesthetic (**Liu, 2021**).

#### **Methods of fundus examination:**

##### **✚ Non-Photographic methods:**

##### **❖ Direct ophthalmoscopy:**

The direct ophthalmoscope has the advantage of being relatively easy to use on co-operative patients. It provides a reasonable magnification of x15 for the emmetropic eye. Another advantage is that a view of the fundus can be obtained without the use of a mydriatic drug making it an important technique for "routine" examinations and in countries where optometrists cannot use mydriatics (**Tekin et al., 2018**). However, because it is a monocular technique, stereopsis is not afforded and also the field of view is poor, only 10° in the emmetropic eye (two disc diameters). Another disadvantage is the relatively poor illumination as compared to indirect techniques but with the clear media of most children, this is less of a disadvantage (**Liu, 2021**). A useful fundus examination with the direct ophthalmoscope can be obtained on co-operative young children (3 years and over) but younger children and infants more difficult. It is important to seek anatomical details, particularly the disc and macular (**Wang, 2023**).

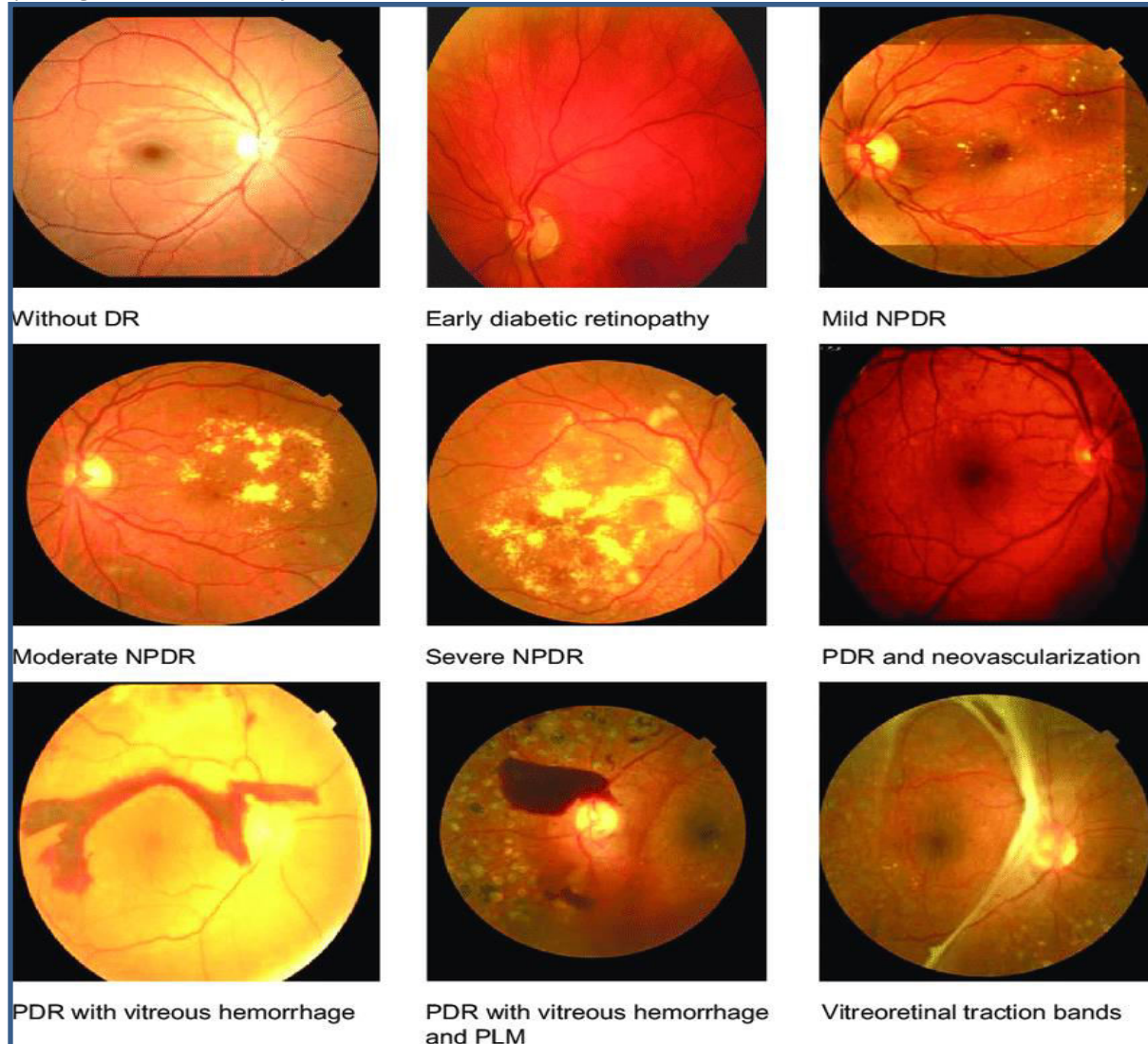
##### **❖ Indirect ophthalmoscopy:**

Indirect methods of ophthalmoscopy employ a condensing lens to form an inverted and laterally reversed image which the optometrist then views. The main advantages of indirect systems is Stereopsis and large field of view making changes in colour and elevation easier to detect. The illumination is also brighter than direct making viewing through media opacities easier (**Tang et al., 2018**). The head set indirect is a very important technique for babies and children and, depending on the power of the condensing lens used may give between 45° to 60° field of view. This technique should be used prior to direct to obtain an overall view or impression of the retina with a + 20 D lens giving a compromise with regard to magnification and field of view. A +30 D may be used to obtain a larger field and a +14 D used to obtain greater detail. It is necessary to dilate the pupil with an anti-muscarinic (**Tekin et al., 2018**). The combination of slit lamp microscope with a fundus lens (e.g., Volk) is also a very useful technique but the ability to carry out this technique is affected more by the co-operation of the patient. The potential field of view with, for example, a +90 D Volk Superfield is 120°, although the field of illumination employed is much less (**Patel et al., 2019**). The magnification of the image is x 0.7 and, when this is viewed through the slit lamp with a x 20 magnification, then a similar magnification to that of direct is obtained but with the added advantages of good illumination, stereopsis and wide field of view. The use of a mydriatic is preferable although with a naturally large pupil, a 3-D view of the disc can be sometimes obtained without dilating (**Liu, 2021**).

##### **✚ Photographic methods:**

❖ **Fundus photography:**

Digital fundus cameras are superb for photographing children aged 3 or 4 years and older. Routine use helps in terms of serial comparison and is especially helpful in comparing optic nerve appearances over time (*Wang, 2023*). Children and adolescents with T1DM are offered regularly eye screenings with fundus photography at fixed intervals to reduce risk of blindness. International Society for Pediatric and Adolescent Diabetes (ISPAD) recommends screening for retinopathy from 11 years of age, at onset of puberty if this is earlier, or after 2-5 years of diabetes duration (*Donaghue et al., 2018*).



**Figure (2):** Fundus images of normal (background retinopathy), mild NPDR, moderate NPDR, severe NPDR, PDR, PDR with new vascularization, and PDR with PLM and with vitreous hemorrhage. Abbreviations: PDR, proliferative diabetic retinopathy; NPDR, nonproliferative diabetic retinopathy; PLM, previous laser marks (*El-Bab et al., 2012*).

### ❖ **OptoMap Laser Scanning Ophthalmoscope:**

This instrument offers a breakthrough in paediatric eye care with a number of advantages. No mydriatic is required for pupils larger than 1 ¾ mm; a field of view of up to 200° is photographed and a view of retina and choroid may be viewed separately or combined (*Tang et al., 2018*). The confocal system means that everything is always in focus. This means that lining up the baby exactly is less critical, and that a view, even if not the full field, is obtained. Images can be obtained at any age. The youngest demonstrated in this lecture is that of a 3 month old infant (*Tekin et al., 2018*).

### **Conclusion and recommendations:**

Fundus photography and direct ophthalmoscopy must be considered as golden tools for screening DR. Further larger, multi-center studies are recommended to evaluate the accuracy of fundus photography versus direct ophthalmoscopy.

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