Wide-Field Retinal Imaging of Retinal and Choroidal Tumors

12

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Wide-field imaging is important in the field of ocular oncology. This technology allows a panretinal image that includes tumor margins and relationships to surrounding structures with imaging of associated features and, most importantly, allows for accurate planning of tumor therapy. Several tumors in the eye arise from the retina, retinal pigment epithelium (RPE), choroid, and optic disc. Some of these tumors are benign and others are malignant. Wide-field imaging, in conjunction with other diagnostic testing, has improved our understanding of ocular tumors and provided better documentation of tumor appearance and effects. In this chapter, we provide images of intraocular tumors with various wide-field cameras.

Tumors of the Retina

The neurosensory retina is composed of neural, glial, and vascular tissue, each of which can produce specific retinal tumors. Most retinal tumors are congenital or develop in childhood. Some are benign; others are malignant. These tumors include retinoblastoma, retinal astrocytic hamartoma, retinal vascular tumors (hemangioblastoma, cavernous hemangioma, racemose hemangioma, and vasoproliferative tumor), and lymphoid/leukemic infiltrations.

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Retinoblastoma

Retinoblastoma is a highly malignant intraocular tumor of childhood [1–4]. Retinoblastoma accounts for approximately 11 % of cancers in children during the first year of life, and most cases are detected before 5 years old. Worldwide, it is estimated that there are approximately 7,000–8,000 new cases per year. The diagnosis of retinoblastoma is established by recognition of classic clinical and imaging features without the need for biopsy. Retinoblastoma can appear endophytic with tumor invasion into the vitreous or exophytic with tumor invasion under the retina. Management of retinoblastoma includes methods of chemotherapy, radiotherapy, laser photocoagulation, thermotherapy, cryotherapy, and enucleation (Figs. 1, 2 and 3).

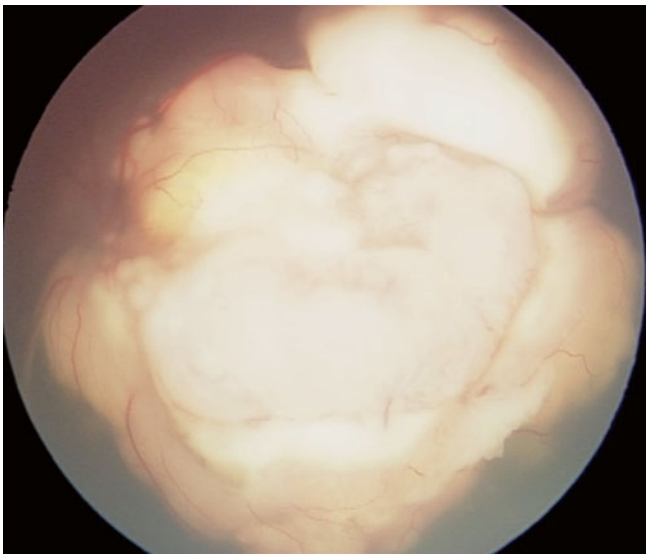

Fig. 1 Endophytic retinoblastoma

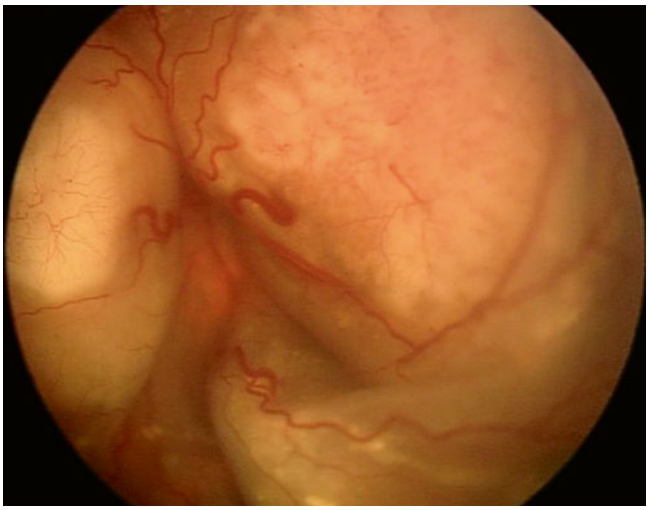

Fig. 2 Exophytic retinoblastoma

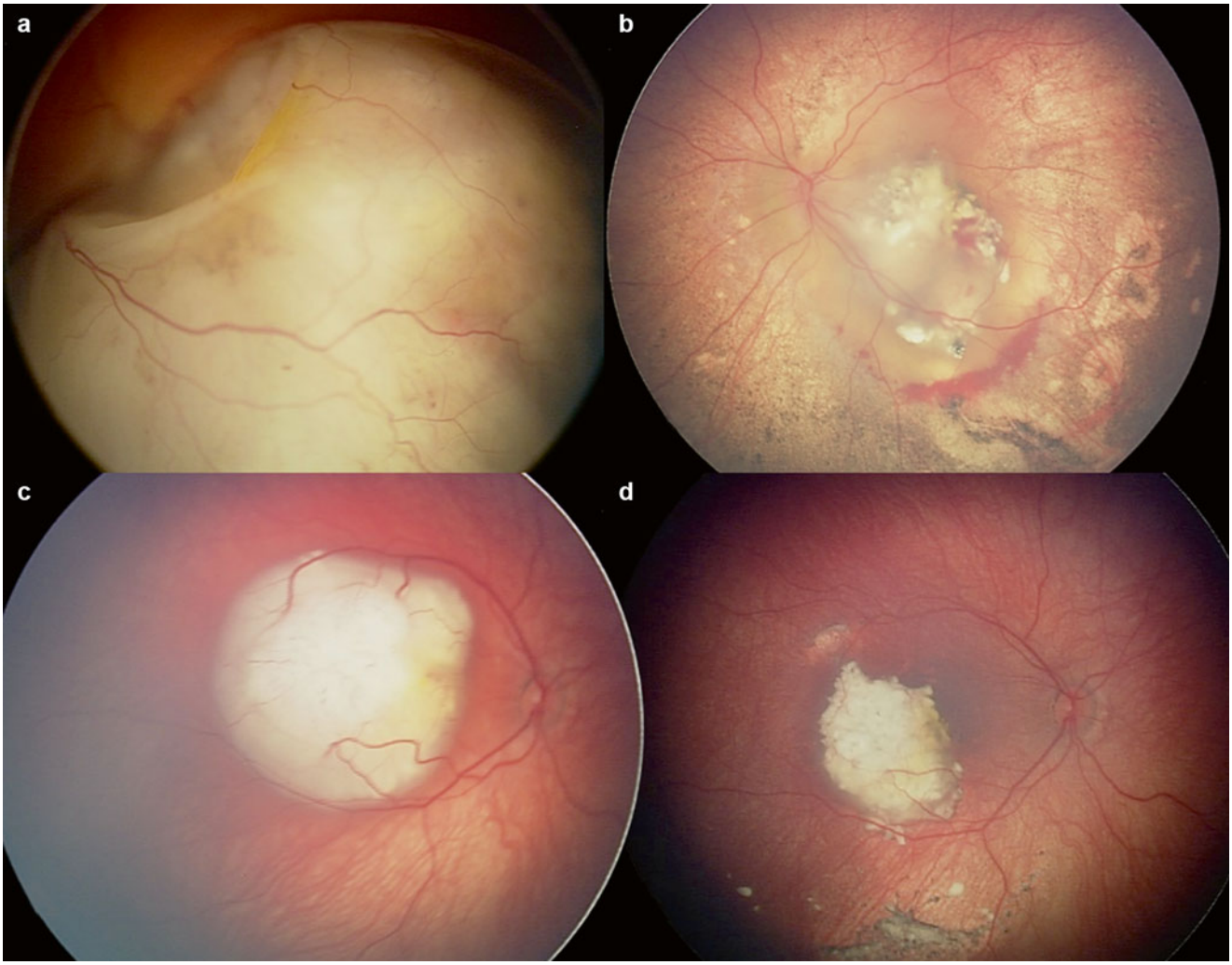

Fig. 3 Retinoblastoma treated with intra-arterial chemotherapy shows advanced retinoblastoma before (**a**) and after (**b**) treatment and less advanced retinoblastoma before (**c**) and after (**d**) treatment, leaving a calcified regressed tumor

Retinal Astrocytic Hamartoma

Retinal astrocytic hamartoma is a benign and classically stable retinal tumor found in patients with tuberous sclerosis complex or as a sporadic condition [5]. This retinal lesion is classified into three morphological groups: types 1, 2, and 3. Type 1 occurs in about 50 % of cases and is characterized by a circular or oval flat semitransparent solitary lesion in the retinal nerve fiber layer with an average size of 0.5 disc diameter [5]. Type 2 shows multiple calcified nodular areas of variable size with a mulberry-like appearance. Type 3 shows features of both type 1 and type 2 with a whitish-gray glistening central calcification and a peripheral semitranslucent, irregular rim. Occasionally, depigmented RPE "punched-out" lesions can be seen with this tumor as part of tuberous sclerosis complex (Fig. 4) [6].

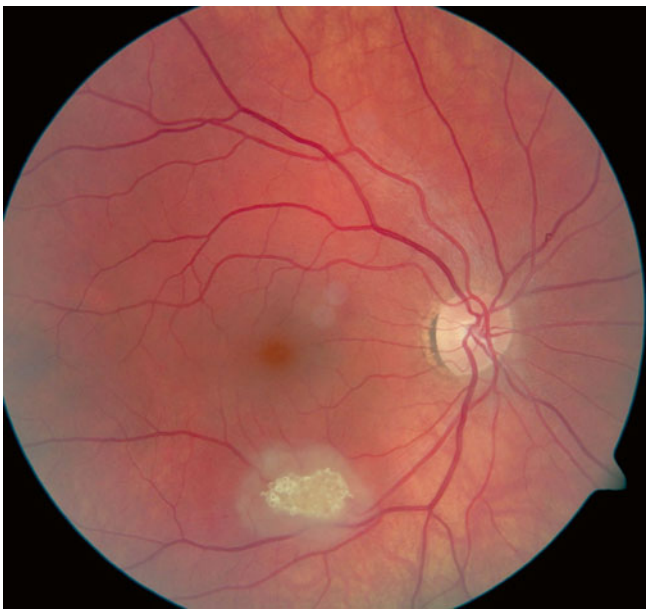

Fig. 4 Retinal astrocytic hamartoma with classic "mulberry-like" calcification

Retinal Hemangioblastoma

Retinal hemangioblastoma is a vascular hamartoma with a circumscribed orange-colored mass with dilated feeding vessels, often producing subretinal fluid and exudation (Fig. 5). This tumor can be a feature of von Hippel–Lindau syndrome [7]. Management includes laser photocoagulation, photodynamic therapy, cryotherapy, plaque radiotherapy, external beam radiotherapy, surgical resection, or anti–vascular endothelial growth factor (anti-VEGF) medications.

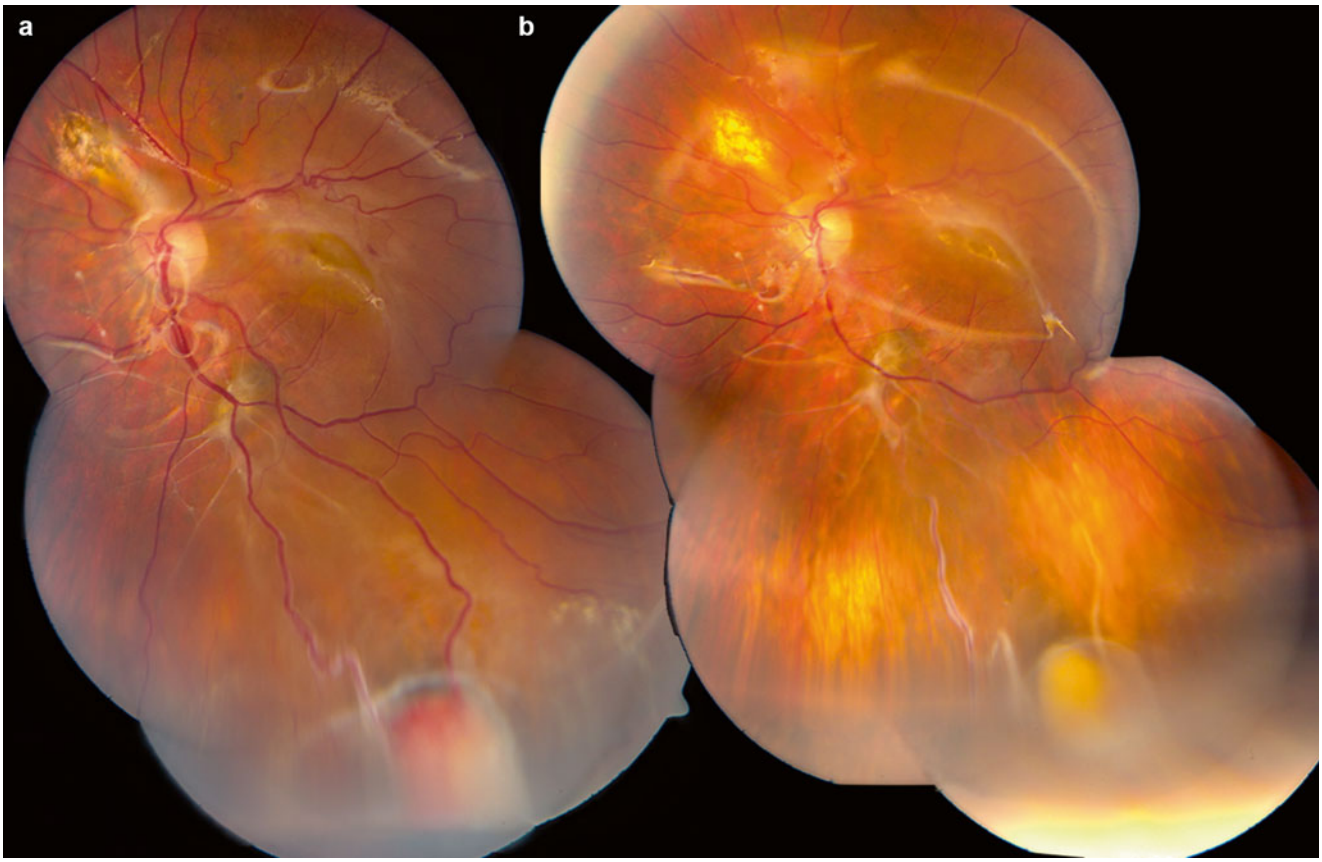

Fig. 5 Retinal hemangioblastoma following vitrectomy with silicone oil tamponade before (**a**) and after (**b**) photodynamic therapy

Retinal Cavernous Hemangioma

Retinal cavernous hemangioma is a vascular hamartoma with little potential for growth, but it can produce vitreous hemorrhage (Fig. 6). This can be a feature of a syndrome of cavernous hemangioma of the brain, skin, and eye. Management is typically observation.

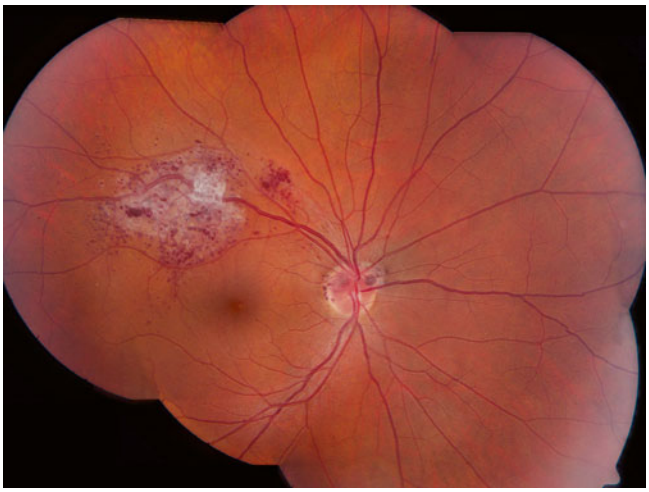

Fig. 6 Retinal cavernous hemangioma appearing like a "bunch of grapes" along the superotemporal vein with overlying preretinal fibrosis and over the optic disc

Retinal Racemose Hemangioma

Retinal racemose hemangioma is vascular malformation in which there is a dilated single or multiple retinal vessels without intervening capillary system, producing a vermiform vascular anomaly (Fig. 7). Occasionally, a vascular obstruction is noted. This lesion can be a feature of the Wyburn-Mason syndrome. Management is observation.

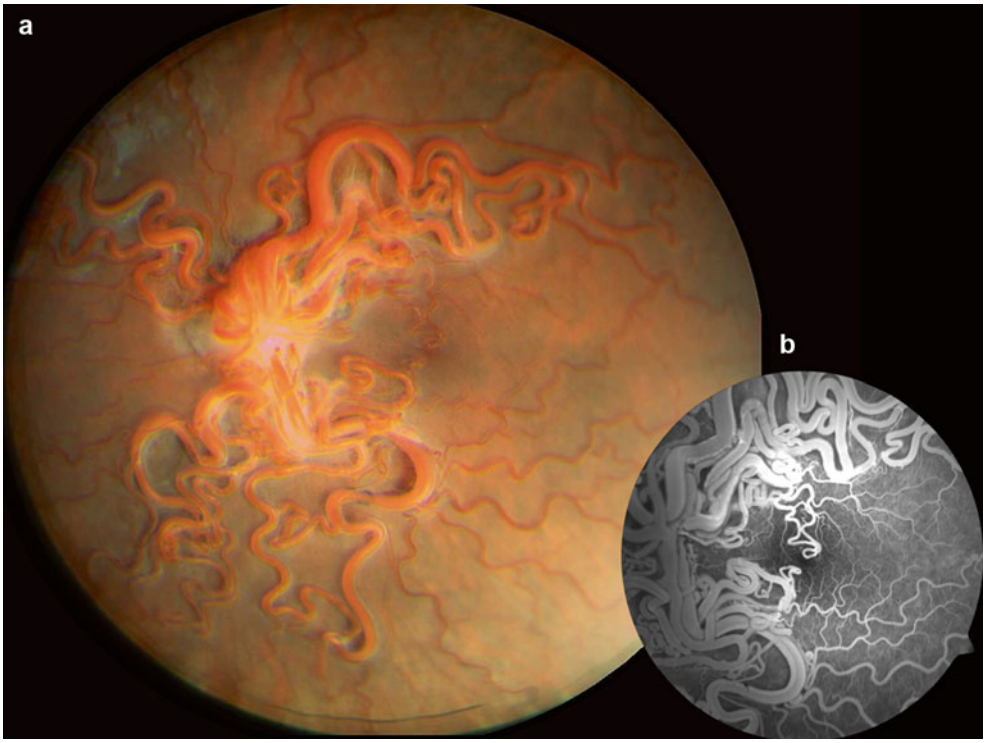

Fig. 7 Retinal racemose hemangioma shows the "vermiform" appearance without capillary bed (**a**), confirmed on fluorescein angiography (**b**)

Retinal Vasoproliferative Tumor

Retinal vasoproliferative tumor is an acquired, benign retinal mass, typically located in the inferotemporal periphery and with surrounding exudation and subretinal fluid (Fig. 8) [8–10]. This tumor is classified into primary or secondary lesions. Secondary lesions are found in eyes with retinitis pigmentosa, pars planitis, Coats disease, or other retinal scarring conditions. Management includes observation, laser photocoagulation, photodynamic therapy, cryotherapy, plaque radiotherapy, or anti-VEGF medications.

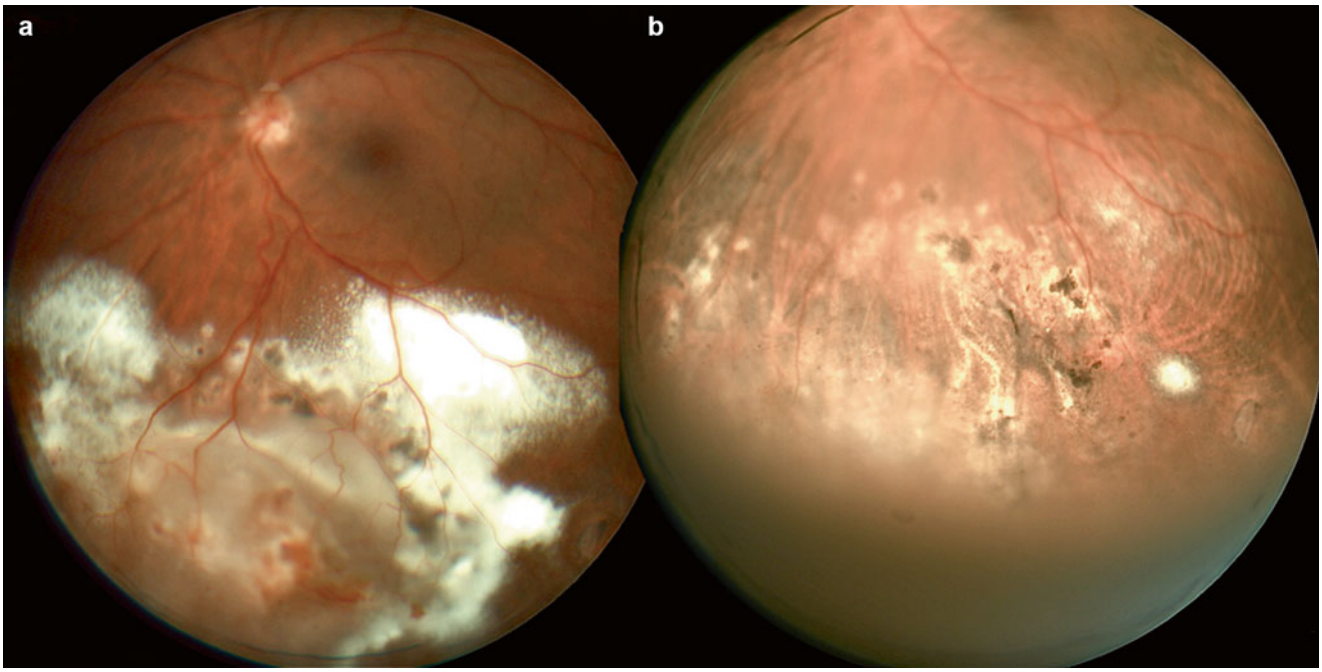

Fig. 8 Retinal vasoproliferative tumor appearing as an ill-defined mass with surrounding exudation, before (**a**) and after (**b**) photodynamic therapy

Retinal Lymphoma/Leukemia

Retinal involvement with lymphoma or leukemia can appear as a white infiltration, occasionally with surrounding hemorrhage [11]. Vitreoretinal lymphoma classically shows sub-RPE tumor and vitreous cells and can have central nervous system lymphoma. Retinal leukemia usually is a late finding with systemic leukemia. Management with systemic chemotherapy is indicated (Figs. 9 and 10).

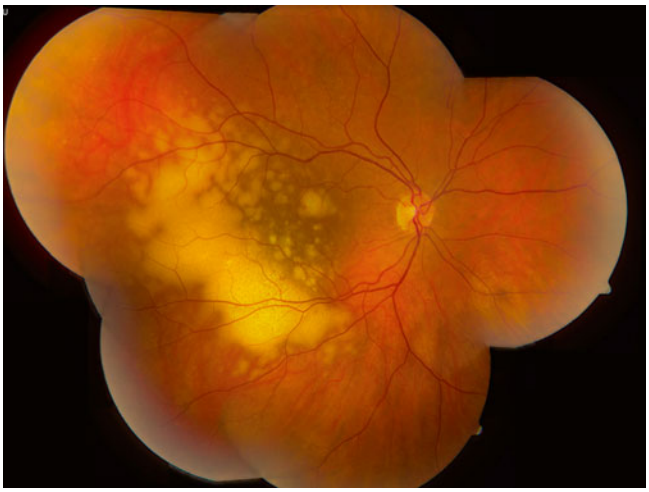

Fig. 9 Vitreoretinal lymphoma with sub-RPE lymphoma deposits in the right eye

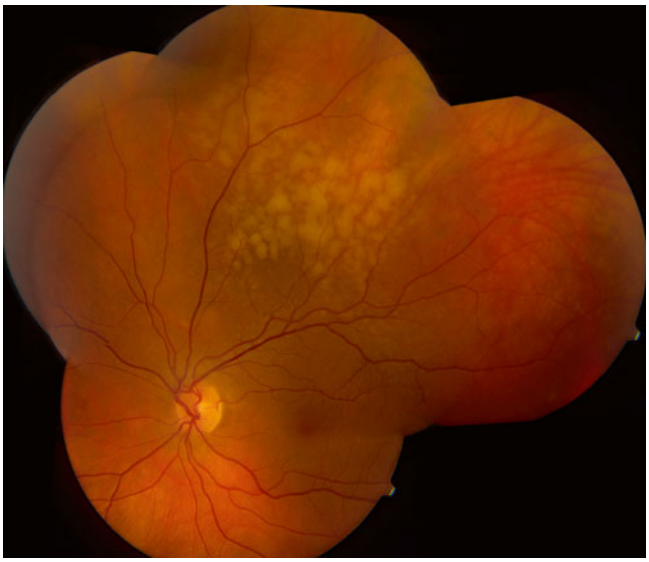

Fig. 10 Same patient as in Fig. 9 with vitreoretinal lymphoma and sub-RPE lymphoma deposits in the left eye

Tumors of the RPE

The RPE is a single-layer epithelium and can spawn several tumors including congenital hypertrophy of the RPE (CHRPE), congenital RPE markers of familial adenomatous polyposis (FAP), congenital simple hamartoma of the RPE, combined hamartoma of the retina and RPE, and adenoma/adenocarcinoma of the RPE.

Congenital Hypertrophy of the RPE

CHRPE is a flat, heavily pigmented benign lesion that classically occurs in the peripheral fundus [12]. The diameter of CHRPE varies from a tiny flat spot to large flat lesion of up to 13 mm with geographic margins and central hypopigmented lacunae [12]. This lesion classically displays sharp margins and can be associated with a surrounding nonpigmented and a complementary pigmented halo [12]. Multifocal CHRPE is known as "bear tracks." Optical coherence tomography (OCT) of CHRPE shows complete lack of photoreceptors over the lesion, and autofluorescence shows complete lack of lipofuscin (Figs. 11 and 12) [13–15].

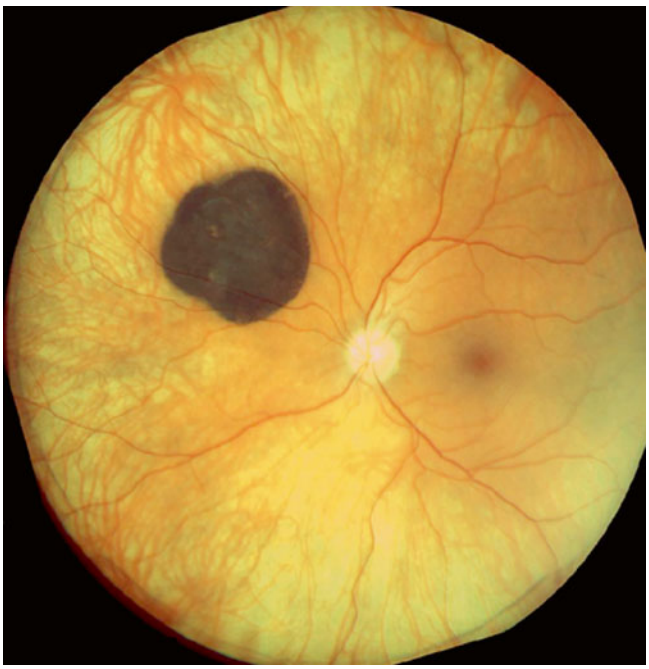

Fig. 11 Solitary congenital hypertrophy of the RPE appearing as a flat black mass

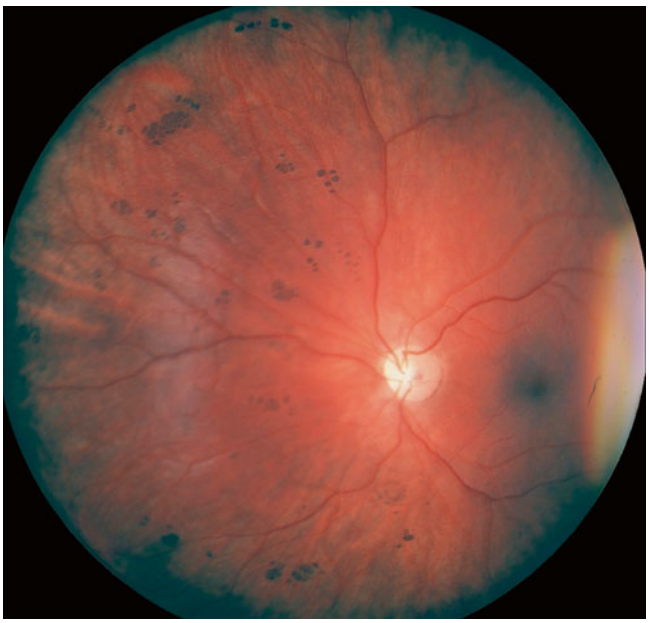

Fig. 12 Multifocal CHRPE appearing as "bear tracks"

Congenital RPE Markers of FAP

Congenital RPE lesions that show pisciform (fishlike) configuration, depigmented tail, or even focal RPE dot can serve as a marker of FAP, especially if the patient has four or more lesions in both eyes (Fig. 13) [16]. These lesions remain stable and require no ophthalmic intervention.

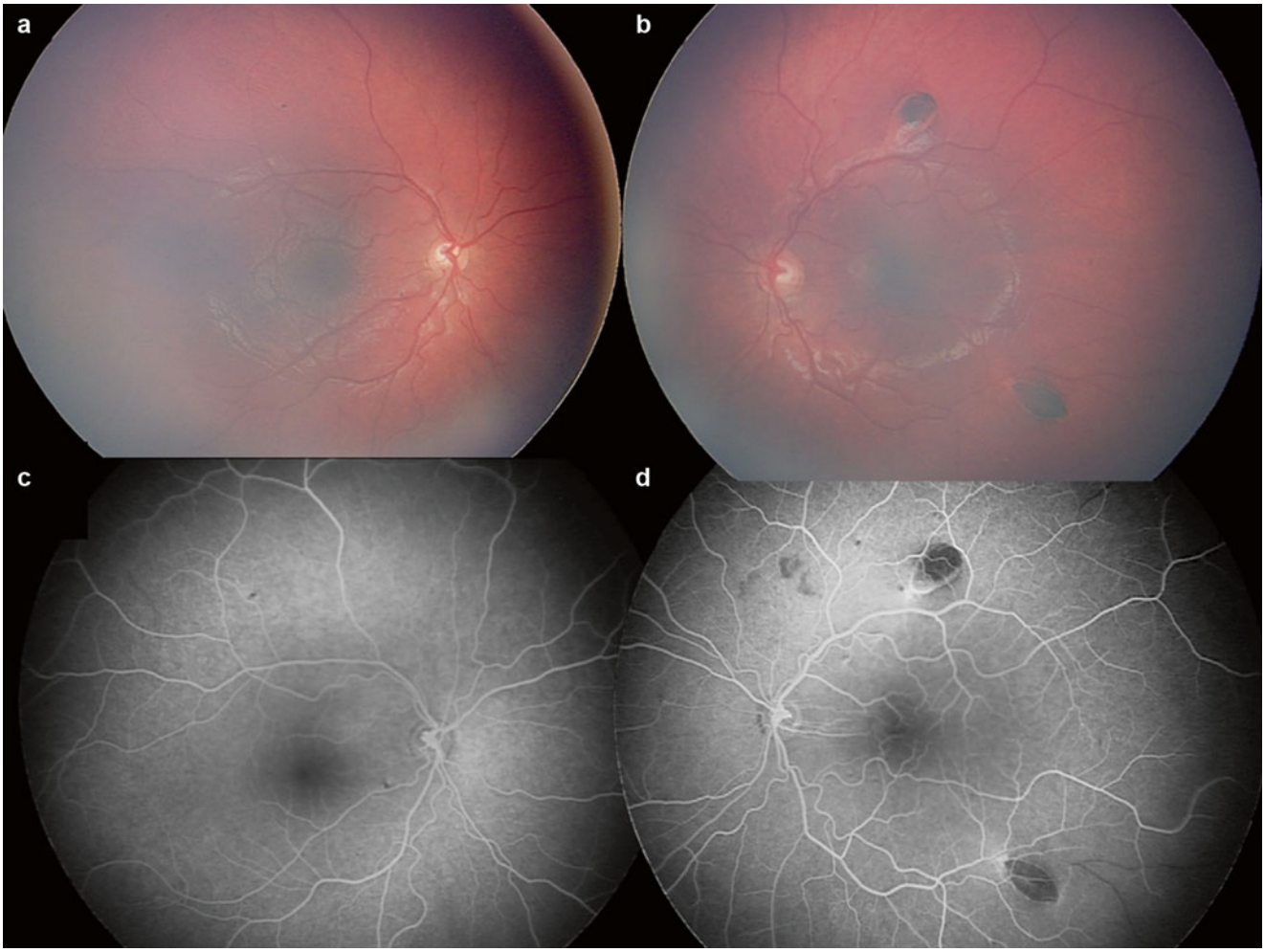

Fig. 13 Congenital RPE markers of FAP show the irregular "pisciform" RPE lesions (**a**, **b**), better seen on fluorescein angiography as focal hypofluorescent spots and dots in both eyes (**c**, **d**)

Congenital Simple Hamartoma of the RPE

Congenital simple hamartoma of the RPE is a dark black, round mass located in the parafoveal region (Fig. 14) [17]. In most cases, visual acuity is normal. This lesion rarely enlarges and requires no intervention.

Combined Hamartoma of the Retina and RPE

Combined hamartoma of the retina and RPE is a benign, presumed congenital condition that can manifest in the papillomacular region or more peripheral near the equator of the eye [18, 19]. This mass displays a mossy green color with retinal traction and tortuosity as well as vitreoretinal traction. Association with neurofibromatosis type 2 and brachial cleft syndrome is occasionally noted (Fig. 15).

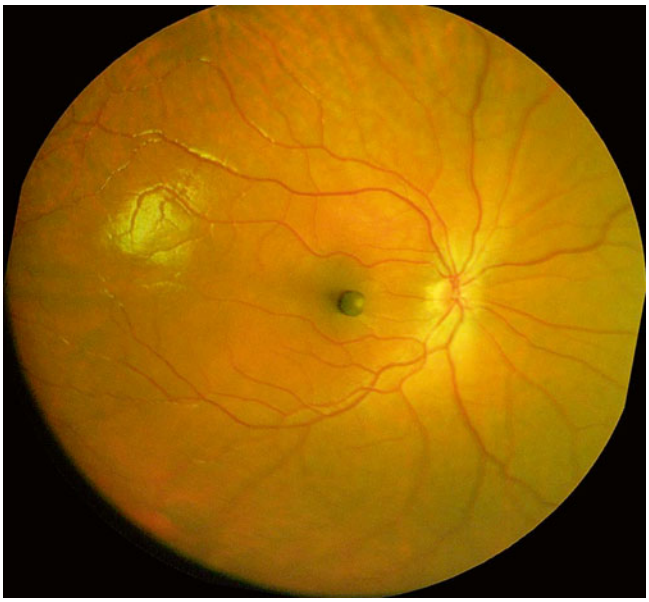

Fig. 14 Congenital simple hamartoma of the RPE appearing as a solitary black lesion near the foveola

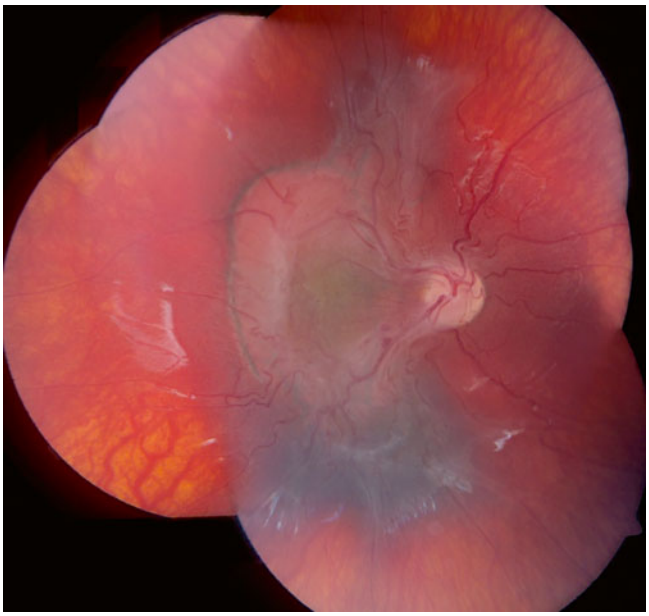

Fig. 15 Combined hamartoma of the retina and RPE appearing as a dark gray mass with extensive retinal traction

Adenoma/Adenocarcinoma of the RPE

The RPE can proliferate into a nodular mass composed of benign (adenoma) or malignant (adenocarcinoma) epithelial cells. Occasionally, surrounding exudation and vitreous hemorrhage is found (Fig. 16).

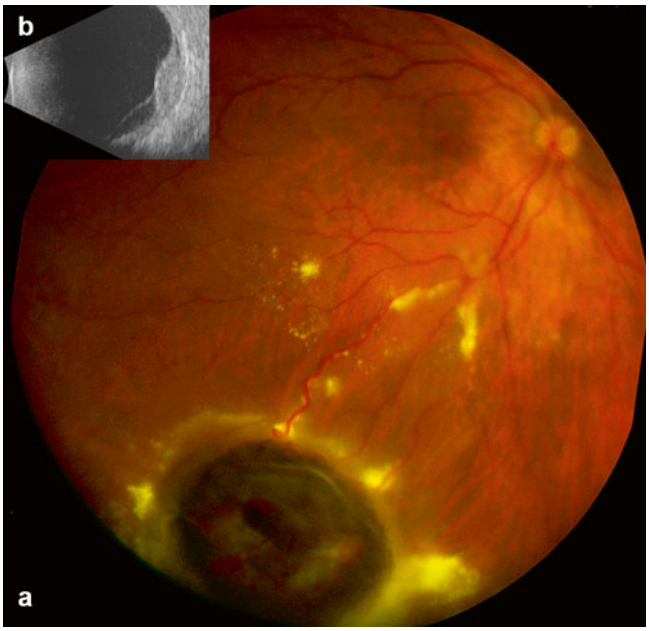

Fig. 16 Adenocarcinoma of the RPE with surrounding exudation (**a**) and appearing echodense with retinal detachment (**b**) on ultrasonography

Tumors of the Ciliary Body Epithelium

The ciliary body epithelium can produce benign or malignant medulloepithelioma of childhood or adenoma/adenocarcinoma of adulthood.

Medulloepithelioma

Medulloepithelioma is a benign or malignant proliferation of the nonpigmented ciliary epithelium that is believed to be a congenital tumor that continues to proliferate after birth. Lens coloboma and neovascular glaucoma are also found in some cases (Fig. 17). Management includes plaque radiotherapy or enucleation.

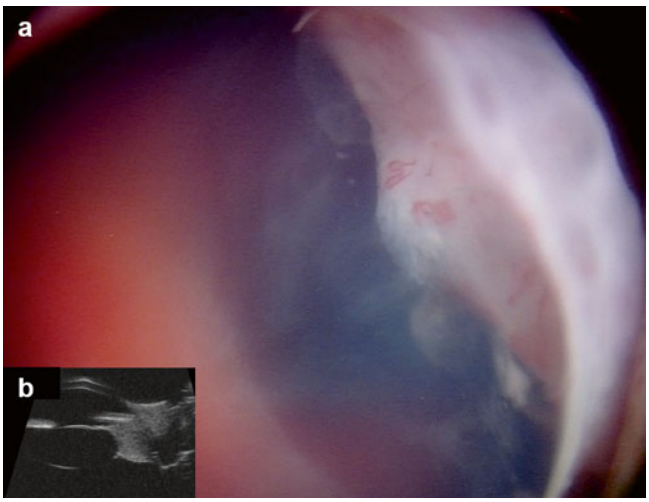

Fig. 17 Medulloepithelioma with intrinsic vascularity and vitreous involvement (**a**) and appearing echodense with posterior cyst (**b**) on ultrasound biomicroscopy

Adenoma/Adenocarcinoma of the Ciliary Body Pigmented or Nonpigmented Epithelium

Adenoma or adenocarcinoma of the ciliary body epithelium typically arises in midadult or older adults as a pigmented or nonpigmented mass located immediately behind the lens. Surgical resection is the treatment of choice.

Tumors of the Choroid

The choroid is composed of melanocytes, vascular elements, and neural tissue, each of which can produce tumors. The most common tumors of the choroid include nevus, metastasis, and melanoma. These lesions can be differentiated based on clinical and imaging evaluations. Occasionally, fine-needle aspiration biopsy is necessary to establish the diagnosis.

Choroidal Nevus

Choroidal nevus is a benign tumor found in approximately 7 % of the Caucasian population [20, 21]. In a population-based study, the mean diameter of choroidal nevus was 1.5 mm [20]. In an ocular oncology clinic-based study, the mean diameter was 5 mm [22]. Choroidal nevus is brown-pigmented in 80 %, and yellow-nonpigmented in 20 % [22]. Overlying drusen (40 %), RPE atrophy (13 %), RPE hyperplasia (9 %), orange pigment (10 %), and choroidal neovascularization (<1 %) can be seen [15]. Transformation into melanoma occurs 1 in 8,845 cases, often identified by risk factors including tumor thickness greater than 2 mm; overlying orange pigment; associated subretinal fluid; symptoms of flashes, floaters, or blurred vision; location of the mass within 3 mm of the optic disc; ultrasound evidence of tumor hollowness, and absence of halo or drusen [23, 24] (Figs. 18, 19, 20, 21, 22 and 23).

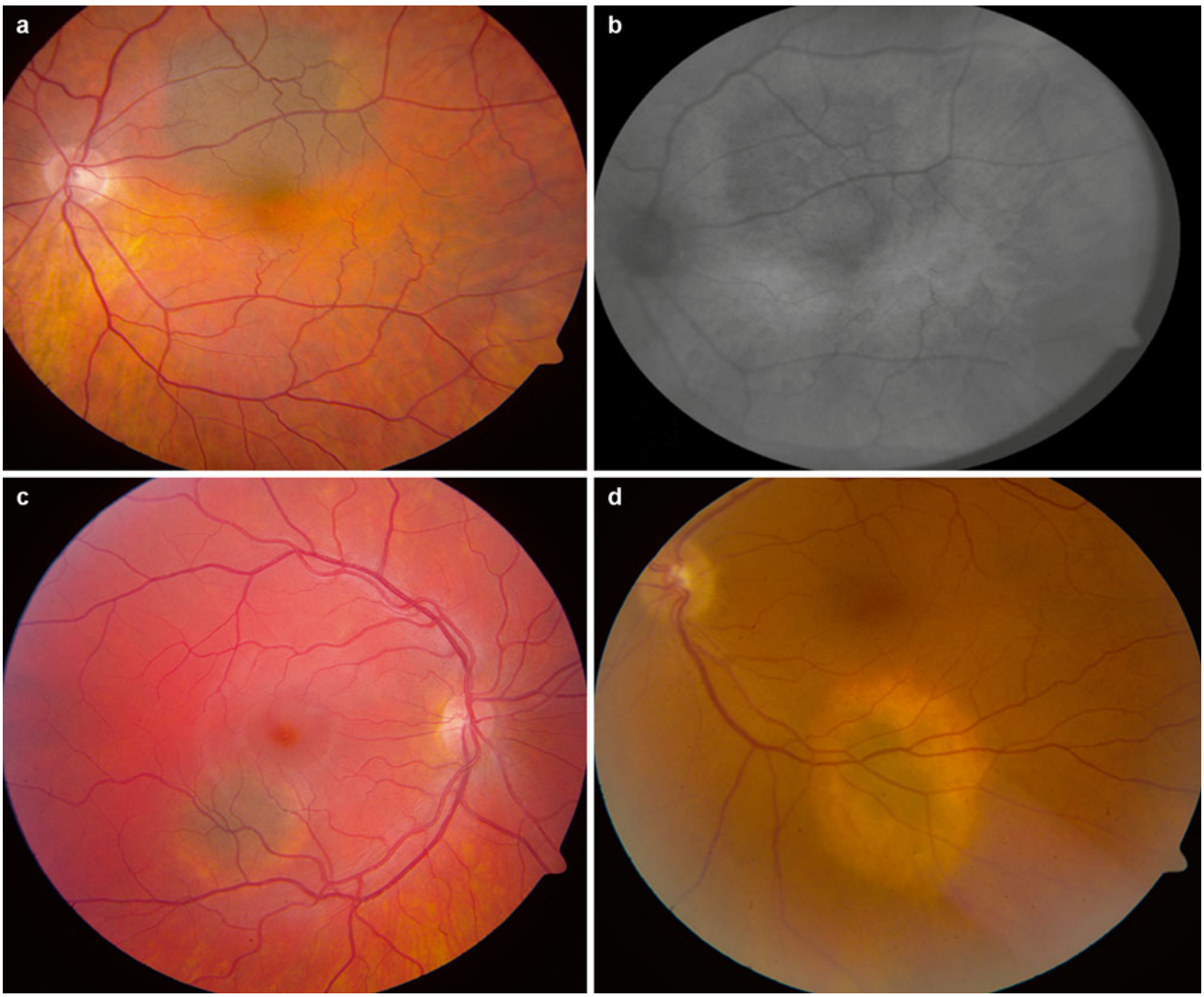

Fig. 18 Choroidal nevus shows dark brown mass (**a**) with hypoautofluorescence (**b**). Halo choroidal nevus in a right (**c**) and a left (**d**) eye of different patients

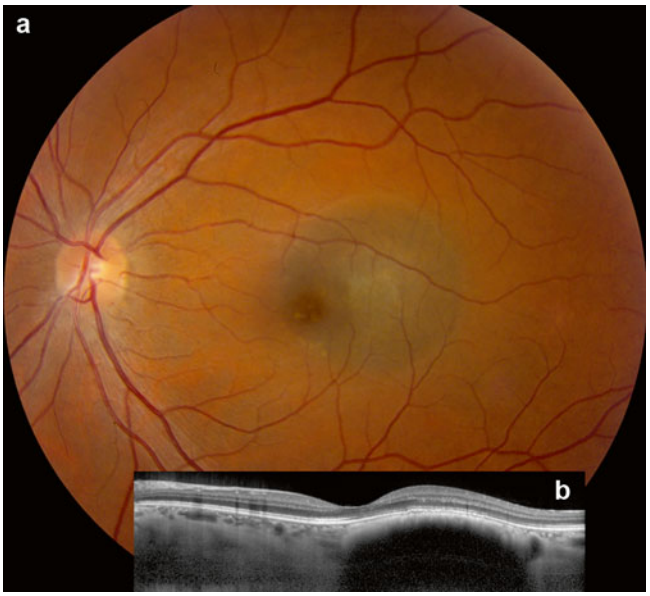

Fig. 19 Choroidal nevus with drusen over the subfoveal portion (**a**) shows optical coherence tomography (OCT) demonstrating optical density with shadowing and overlying RPE alterations (**b**)

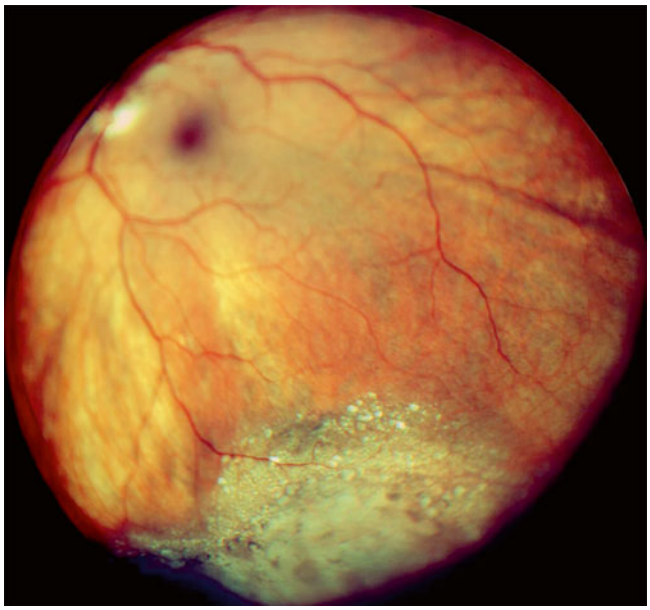

Fig. 21 Large peripheral choroidal nevus with overlying drusen

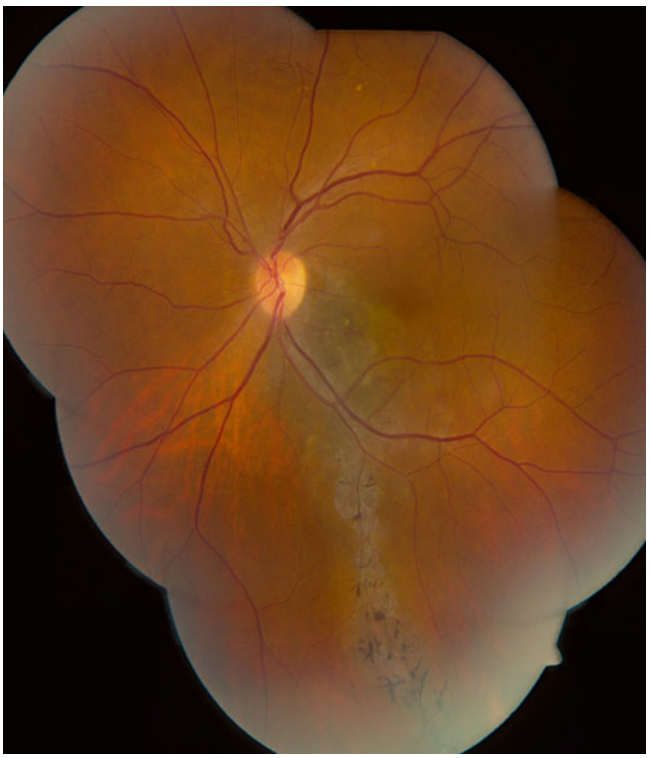

Fig. 20 Choroidal nevus in juxtapapillary region with an old trough of subretinal fluid

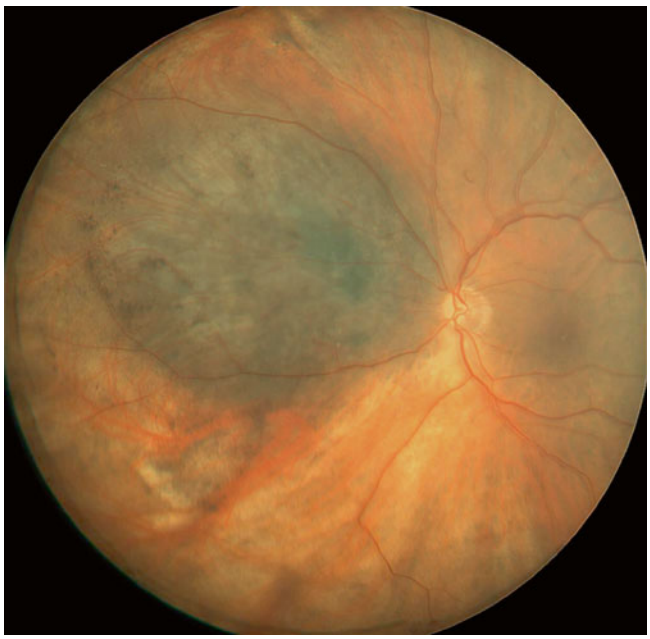

Fig. 22 Large juxtapapillary choroidal nevus with overlying RPE atrophy

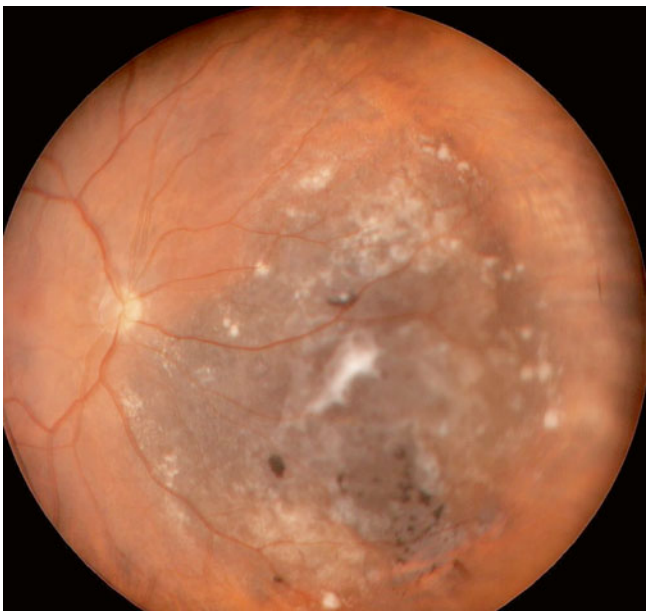

Fig. 23 Large equatorial choroidal nevus with overlying drusen and RPE fibrous metaplasia

Choroidal Melanoma

Choroidal melanoma is a serious, life-threatening intraocular malignancy that appears with a dome or mushroom configuration, often with surrounding subretinal fluid and occasional subretinal or vitreous hemorrhage [25]. Approximately six individuals per million population annually develop this malignancy, with roughly 2,000 new cases in the United States each year. Prognosis of melanoma depends on tumor thickness, with each increasing millimeter imparting 5 % increased risk for metastasis [26, 27]. Treatment includes enucleation, surgical resection, proton radiotherapy, plaque radiotherapy, or thermotherapy (Figs. 24, 25, 26, 27, 28, 29, 30, 31 and 32).

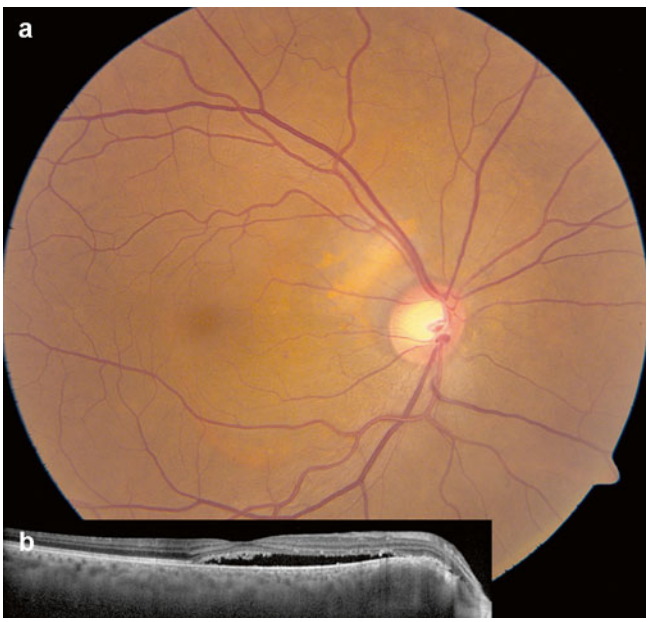

Fig. 24 Small juxtapapillary choroidal melanoma with overlying orange lipofuscin pigment (**a**) and subretinal fluid (**b**) on OCT

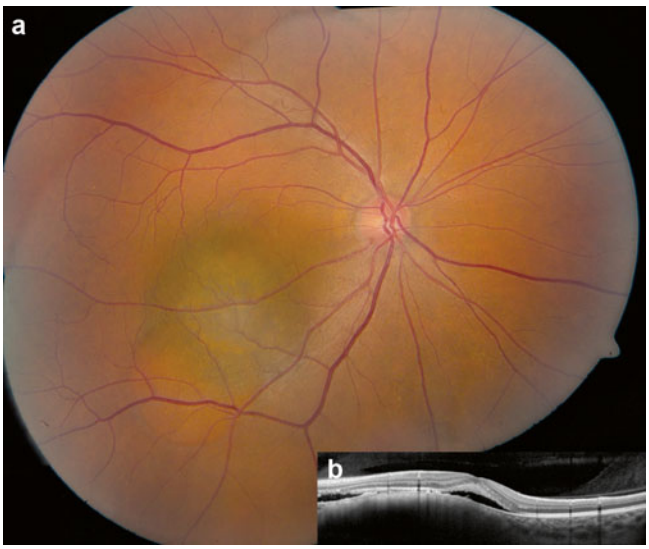

Fig. 25 Small macular choroidal melanoma with overlying and puddled orange lipofuscin pigment (**a**) and subretinal fluid (**b**) on OCT

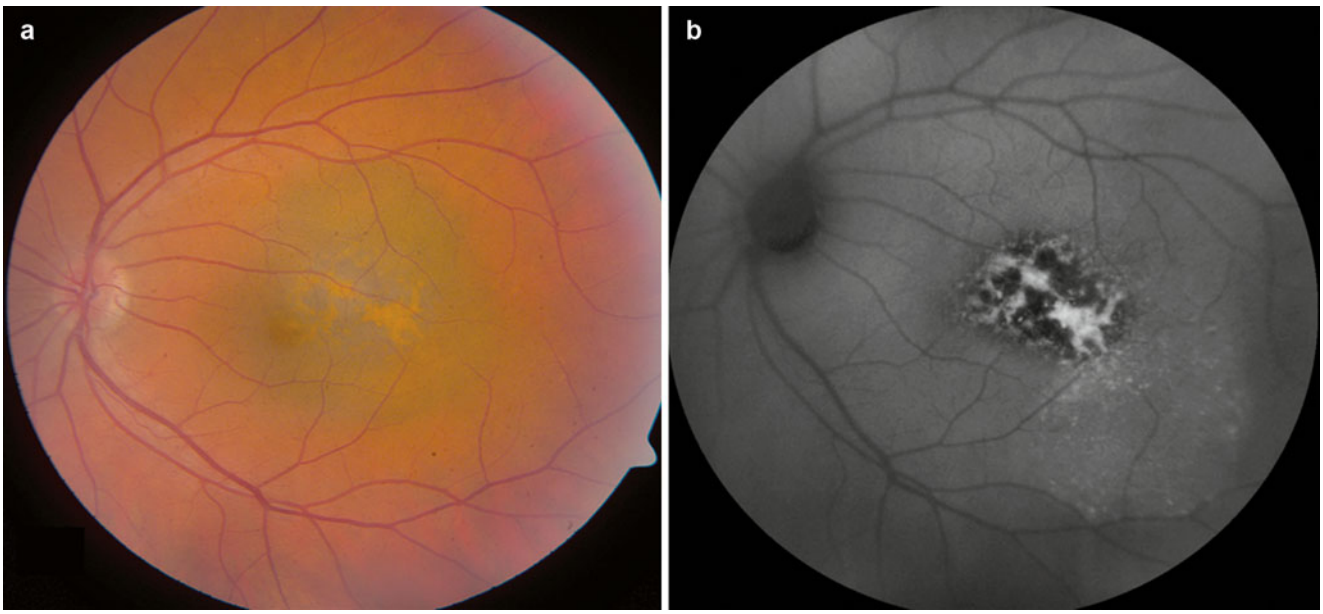

Fig. 26 Small macular choroidal melanoma with overlying orange lipofuscin pigment (**a**), confirmed as hyperautofluorescent (**b**)

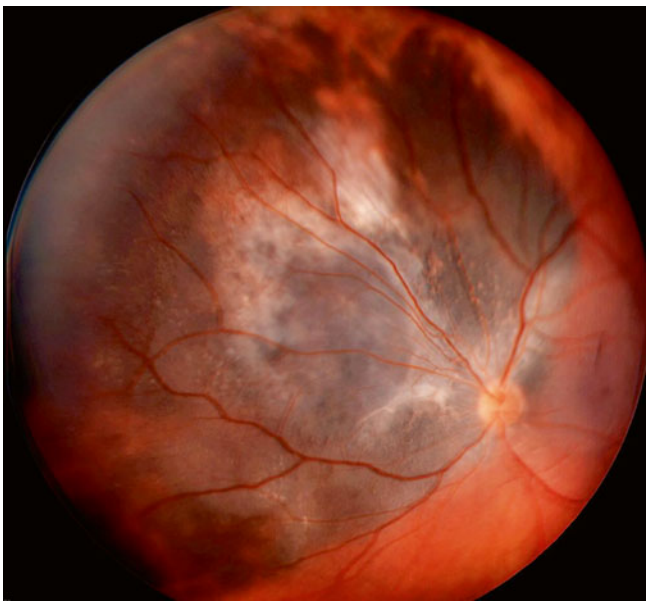

Fig. 27 Diffuse flat melanoma with overlying subretinal fluid and orange pigment

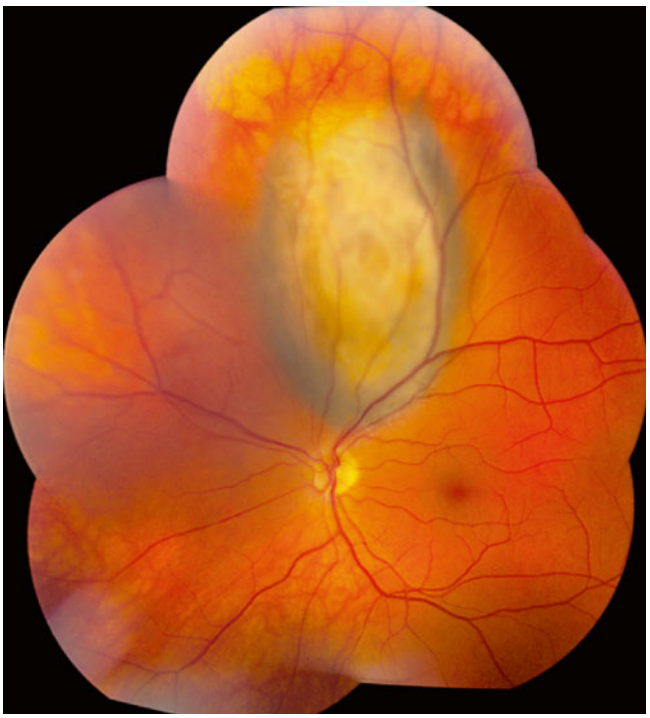

Fig. 28 Medium-size choroidal melanoma

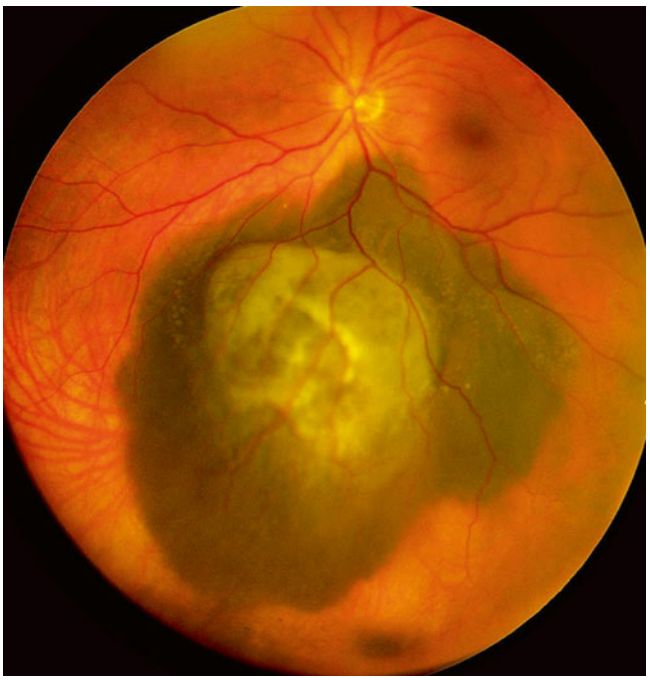

Fig. 29 Medium-size choroidal melanoma with minor overlying subretinal fluid

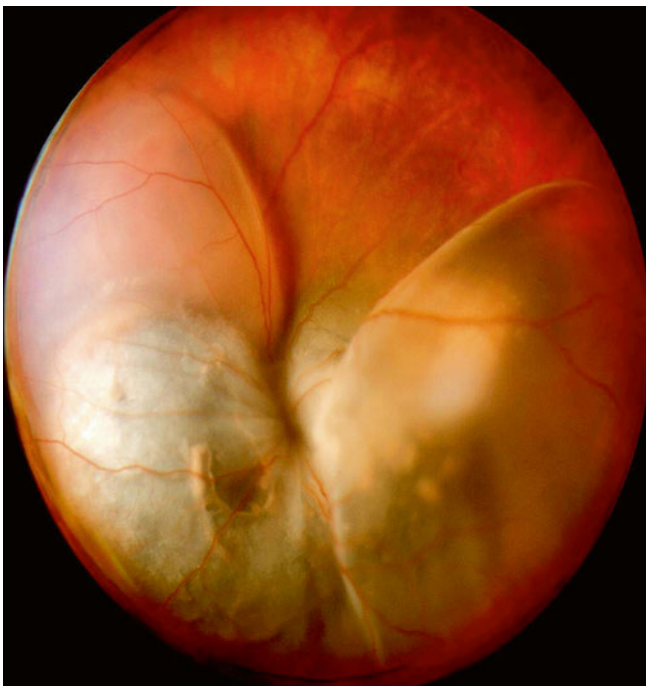

Fig. 30 Medium-size choroidal melanoma with extensive subretinal fluid

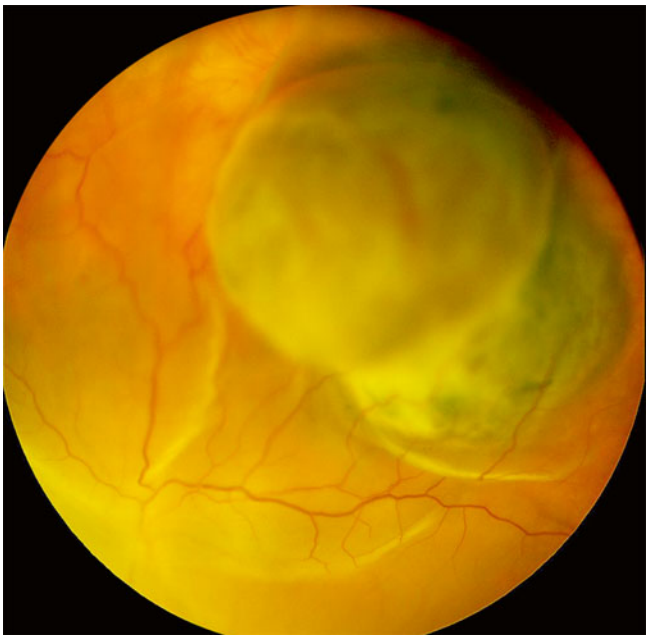

Fig. 31 Large choroidal melanoma with subretinal fluid

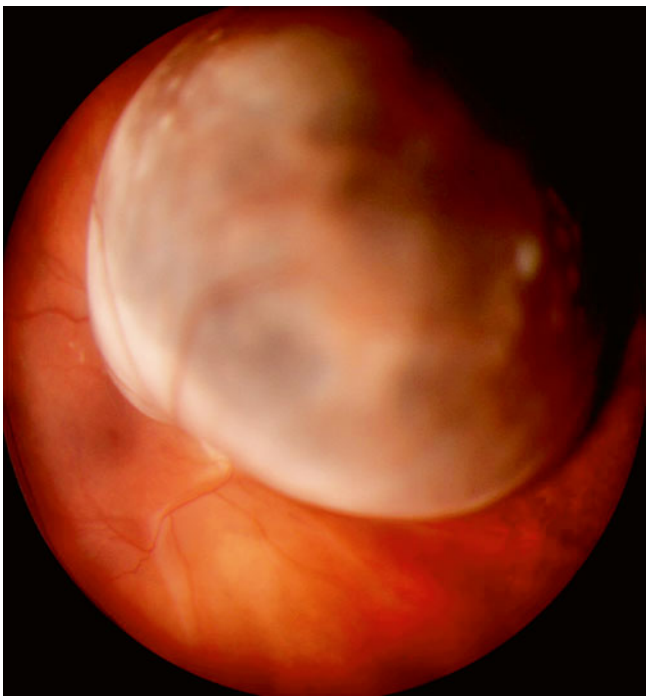

Fig. 32 Very large choroidal melanoma overhanging the optic disc and with subretinal fluid

Choroidal Metastasis

Choroidal metastases appear as a yellow mass, often with subretinal fluid. This malignancy originates from primary breast cancer in 53 %, lung cancer in 20 %, and others [28]. Bilateral metastases are most often secondary to breast carcinoma (70 %) (Figs. 33, 34, 35 and 36) [28].

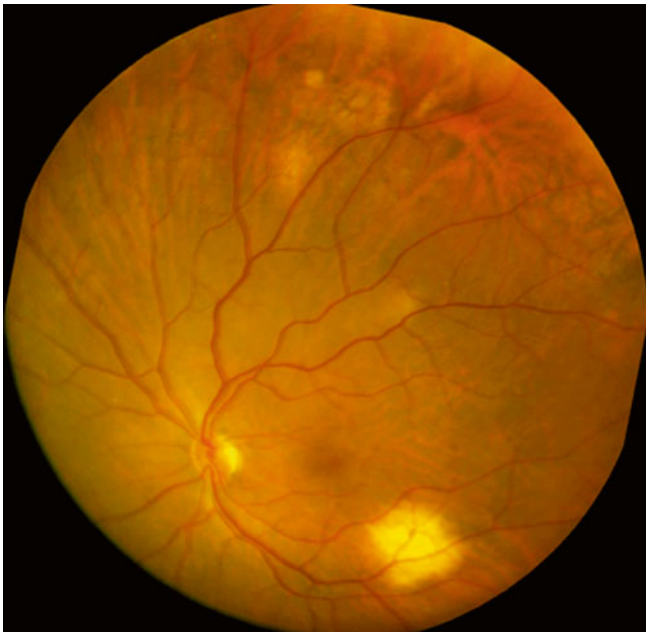

Fig. 33 Small choroidal metastasis inferior to the macular region and three small metastases superior to the macular region

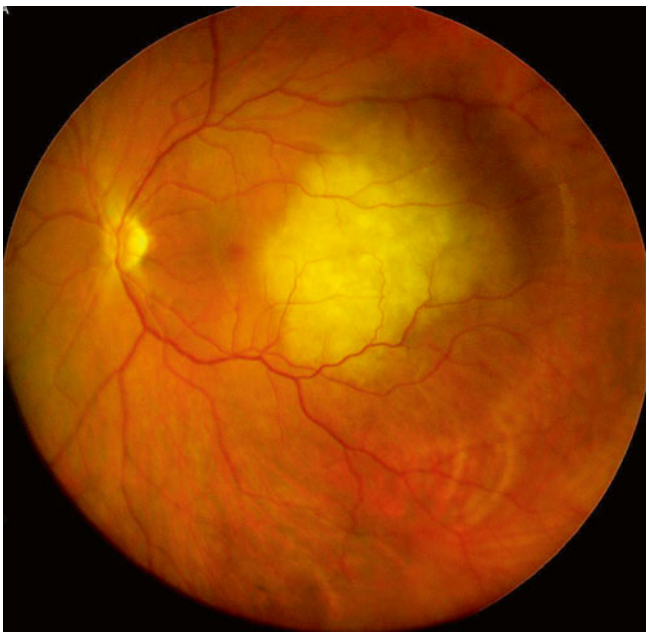

Fig. 34 Medium-size choroidal metastasis with minor subretinal fluid

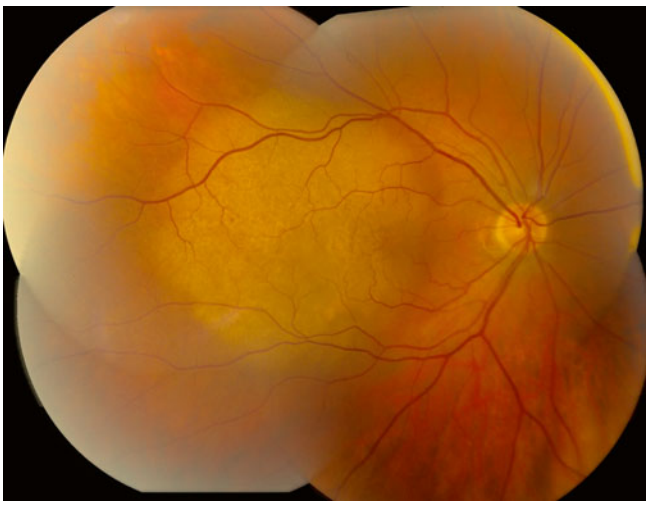

Fig. 35 Medium-size choroidal metastasis with minor subretinal fluid

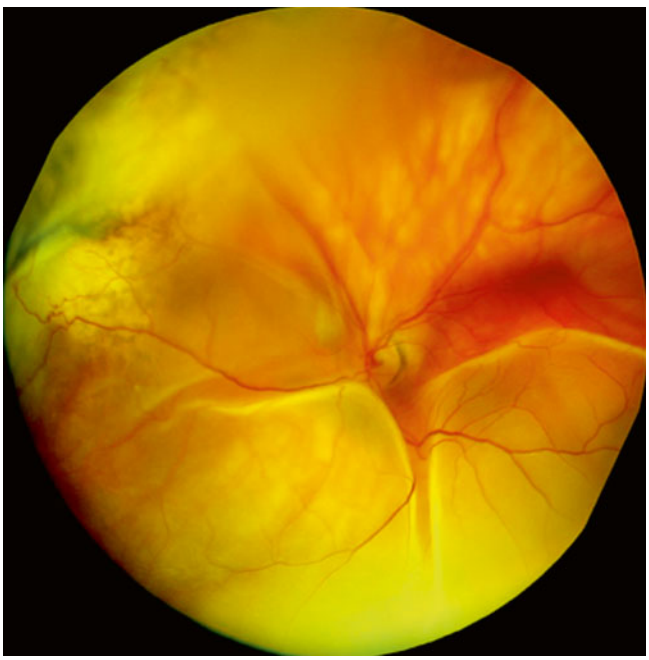

Fig. 36 Extensive choroidal metastasis with extensive subretinal fluid

Choroidal Hemangioma

Choroidal hemangioma can appear as a circumscribed or diffuse vascular mass. The circumscribed lesion appears as a circumscribed, round, slightly elevated orange mass of mean diameter 6 mm and thickness of 3 mm [29]. This tumor classically occurs in the postequatorial region and exhibits slow enlargement with progressive subretinal fluid or macular edema. The diffuse hemangioma occurs in patients with Sturge-Weber syndrome and can produce total retinal detachment. Management includes photodynamic therapy or radiotherapy (Figs. 37, 38, 39, 40 and 41) [30, 31].

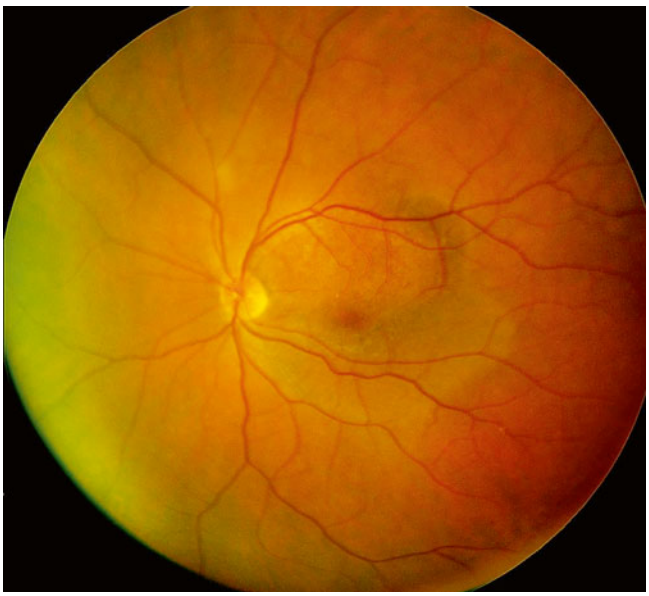

Fig. 37 Small submacular circumscribed choroidal hemangioma with subtle subretinal fluid

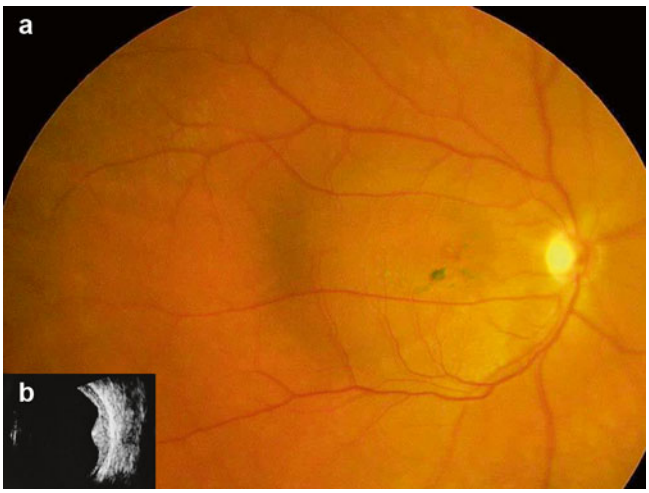

Fig. 38 Moderate submacular circumscribed choroidal hemangioma (**a**), appearing echodense (**b**) on ultrasonography

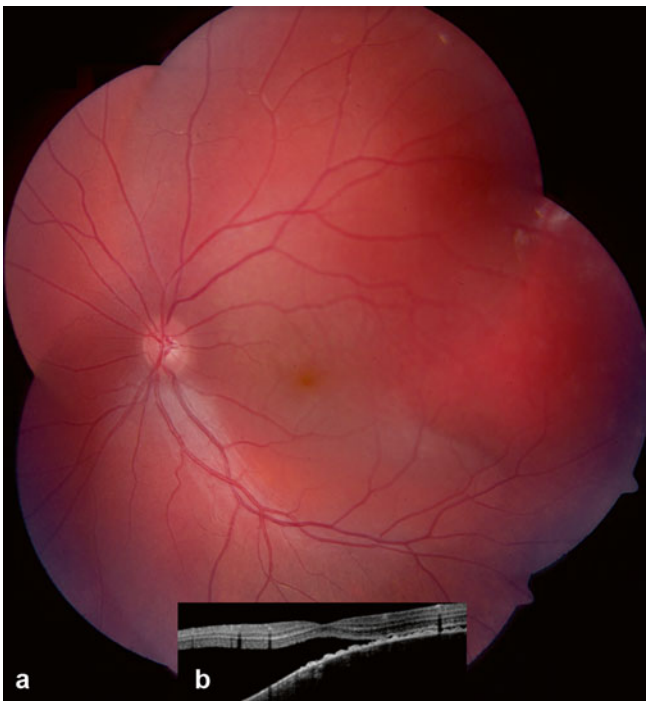

Fig. 39 Diffuse choroidal hemangioma of Sturge-Weber syndrome (**a**) with subretinal fluid (**b**) on OCT

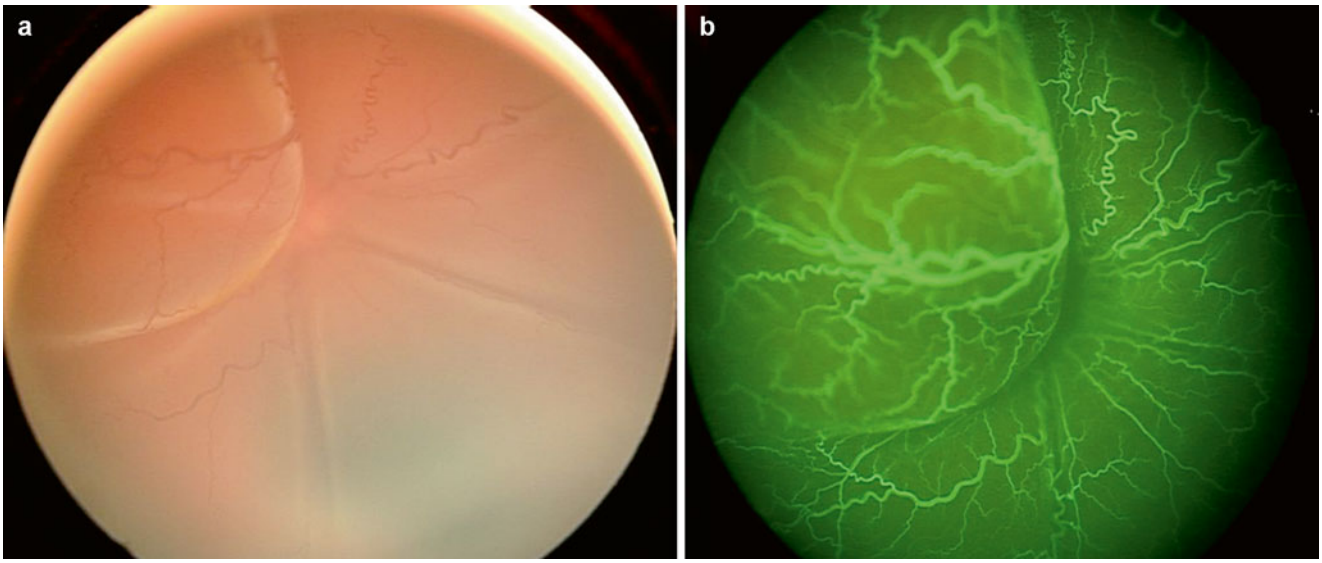

Fig. 40 Diffuse choroidal hemangioma of Sturge-Weber syndrome (**a**) with total retinal detachment (**b**) imaged with fluorescein angiography

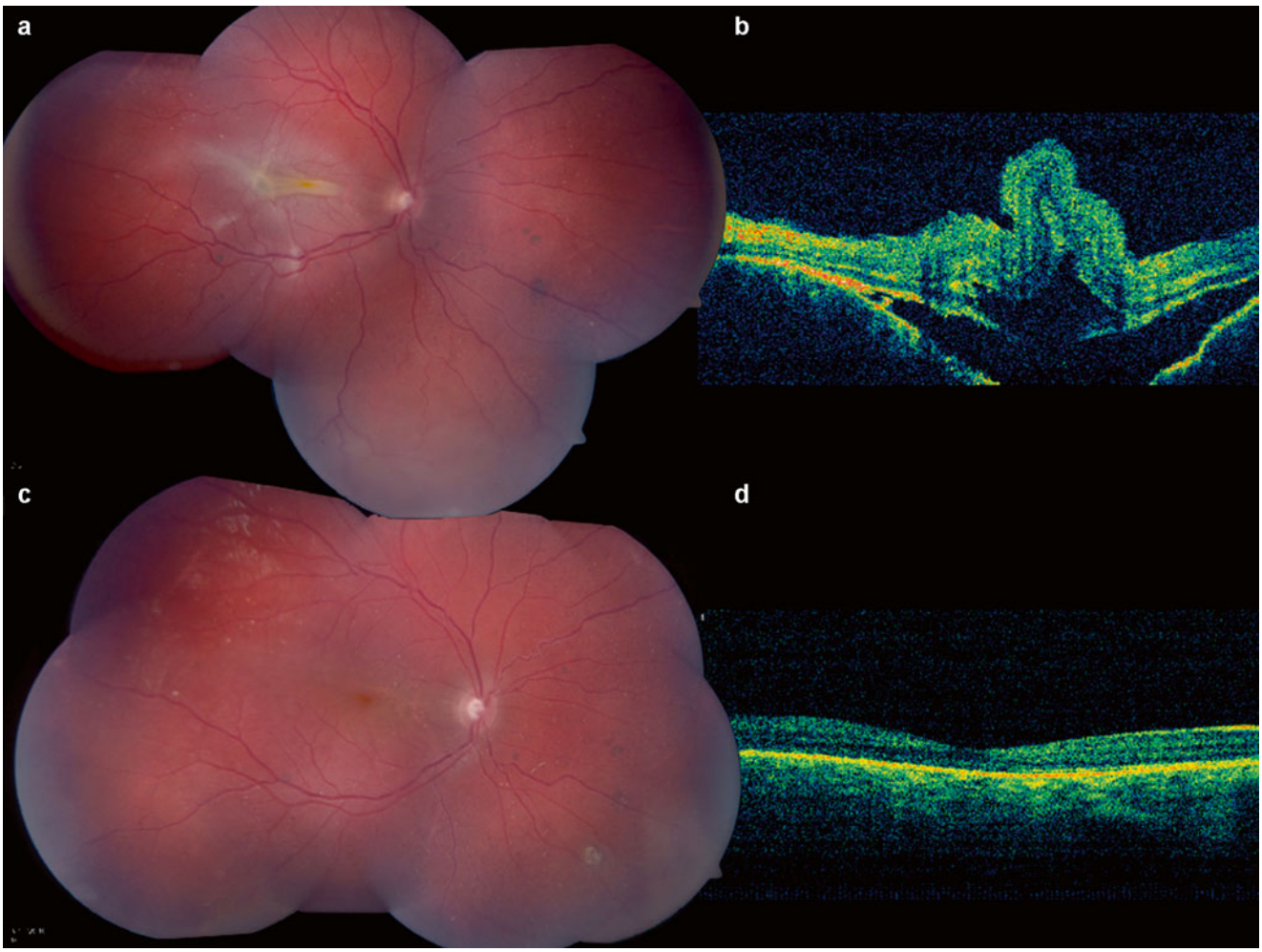

Fig. 41 Diffuse choroidal hemangioma with subretinal fluid before (**a**, **b**) and after (**c**, **d**) radiotherapy

Choroidal Osteoma

Choroidal osteoma is a benign intraocular tumor composed of mature bone [32, 33]. This tumor classically manifests as an orange-yellow plaque deep to the retina in the juxtapapillary or macular region of young women. This tumor can be unilateral (80 %) or bilateral (20 %). The cause and pathogenesis of this tumor are unknown. Ten-year probability for tumor growth is 51 %, tumor decalcification is 46 %, related choroidal neovascularization is 31 %, visual acuity loss of 3 or more Snellen lines is 45 % (Figs. 42, 43, 44 and 45) [33].

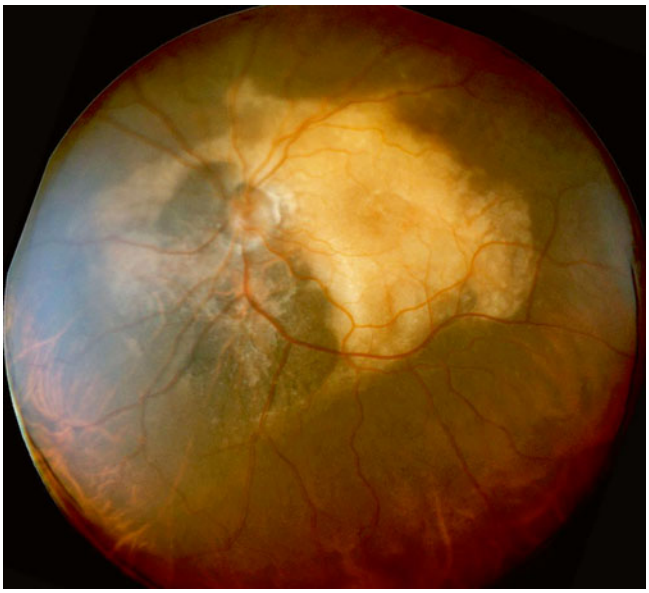

Fig. 42 Choroidal osteoma

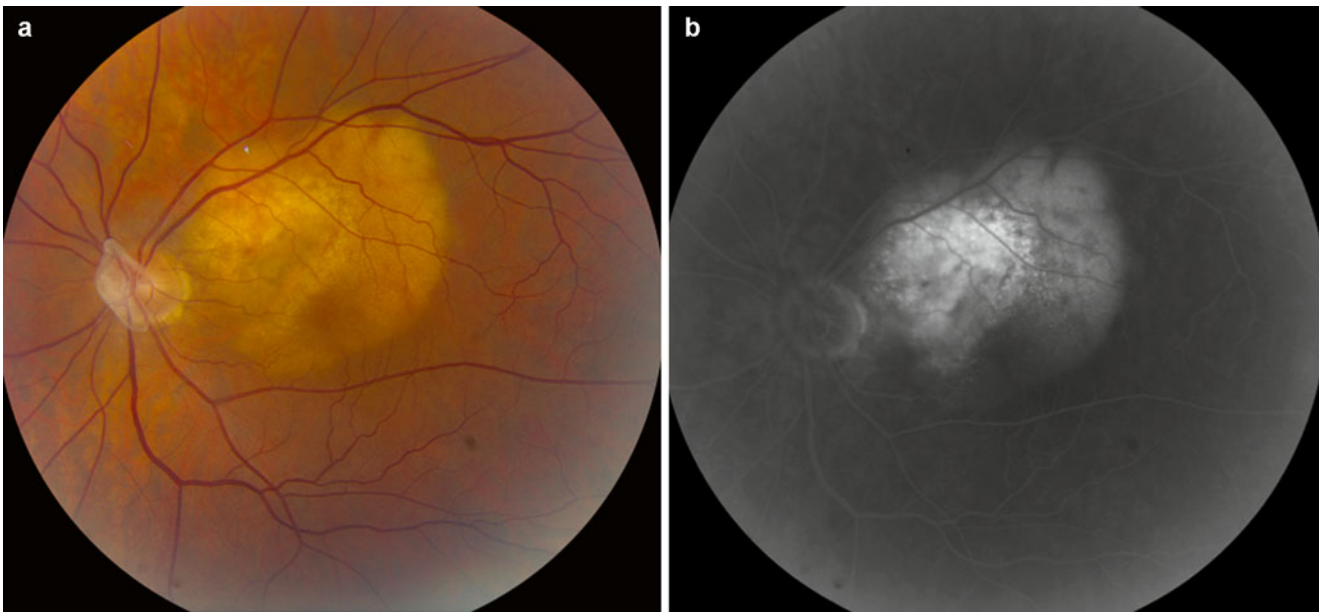

Fig. 43 Choroidal osteoma (**a**) shows hyperfluorescence (**b**)

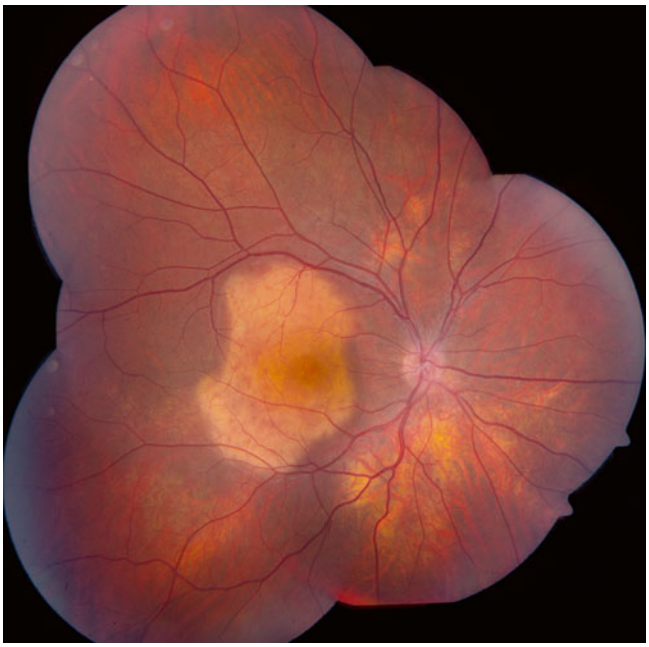

Fig. 44 Choroidal osteoma in the right macula

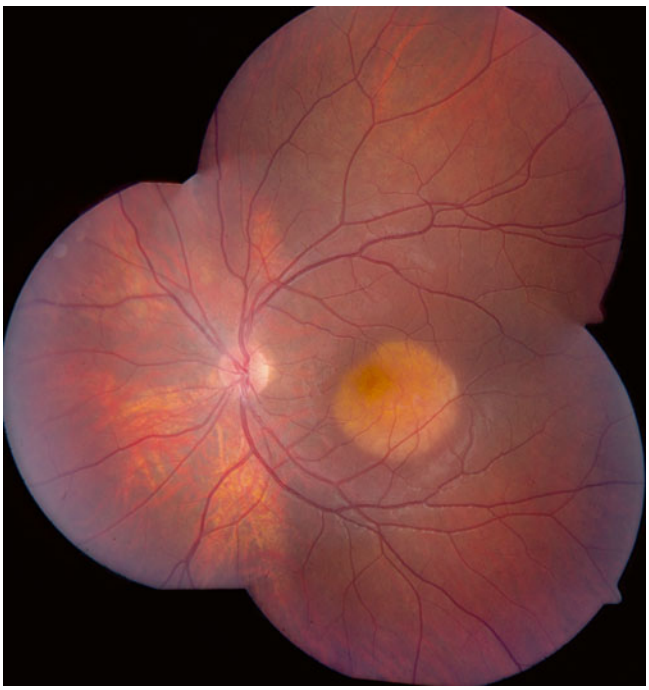

Fig. 45 Choroidal osteoma in the left macula of the patient in Fig. 44

Choroidal Leiomyoma

Ciliary body/choroidal leiomyoma is a benign tumor arising in the suprauveal space [34]. This tumor appears nonpigmented and most often is managed with surgical resection (Fig. 46).

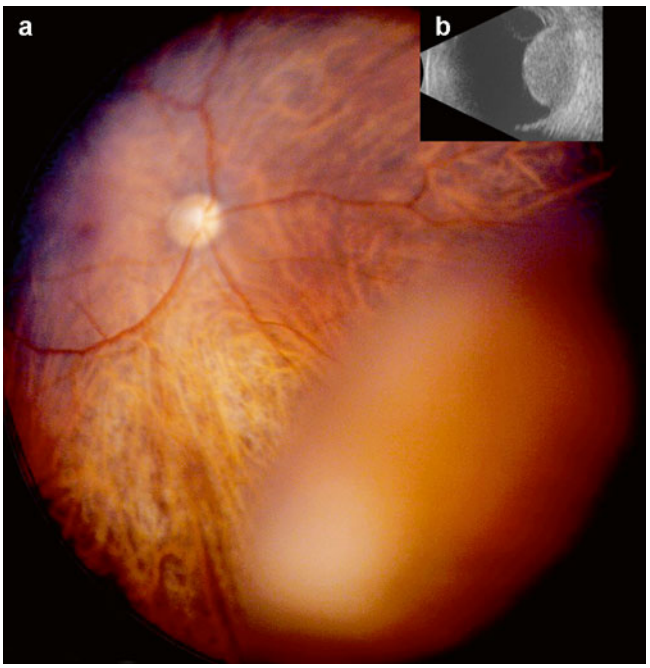

Fig. 46 Ciliochoroidal leiomyoma in the far periphery of the fundus (**a**) and echogenic (**b**) on ultrasonography

Choroidal Lymphoma

Intraocular lymphoma can be divided into uveal and vitreoretinal forms [35]. In the uveal form, the tumor is typically low grade and appears as a placoid thickening of the choroid with occasional overlying subretinal fluid. In the vitreoretinal form, the tumor is high-grade large cell lymphoma and can manifest with vitreous tumor, sub-RPE infiltration, and retinal infiltration. Definitive diagnosis is made through fine-needle aspiration biopsy (Figs. 47 and 48).

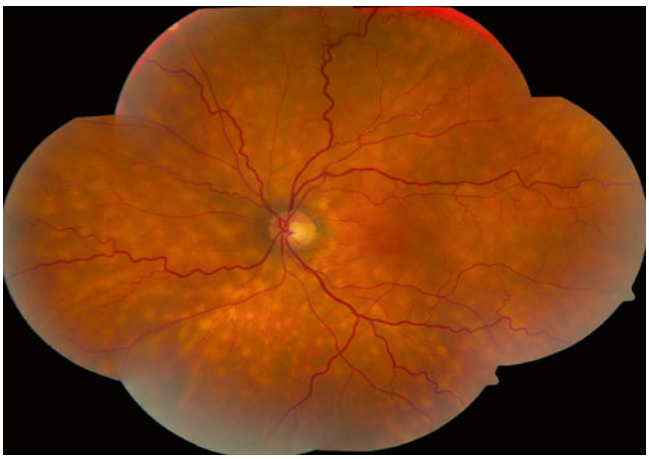

Fig. 47 Choroidal lymphoma with multifocal yellow spots of infiltration

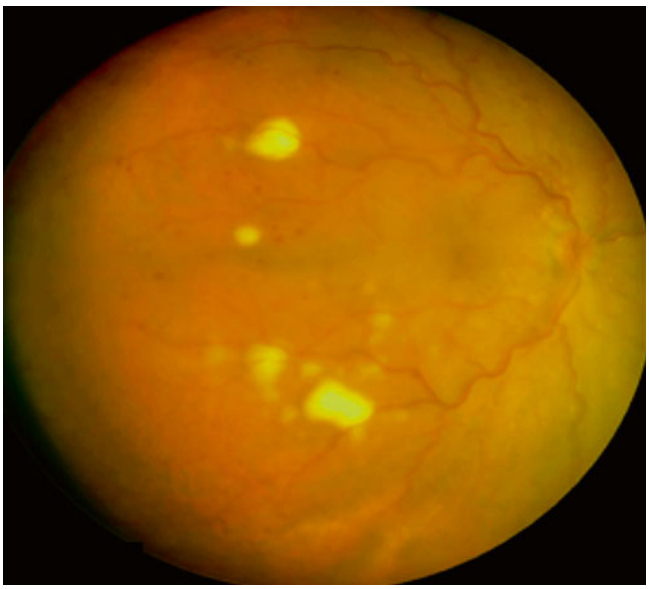

Fig. 48 Vitreoretinal lymphoma with sub-RPE infiltration of lymphoma

Tumors of the Disc

Optic Disc Melanocytoma

Optic disc melanocytoma is a darkly pigmented nevus obscuring the disc details and occasionally causing compression with visual acuity or visual field loss. This benign lesion can slowly grow in 14 % of cases and can rarely transform into melanoma [36]. Management is observation (Figs. 49 and 50).

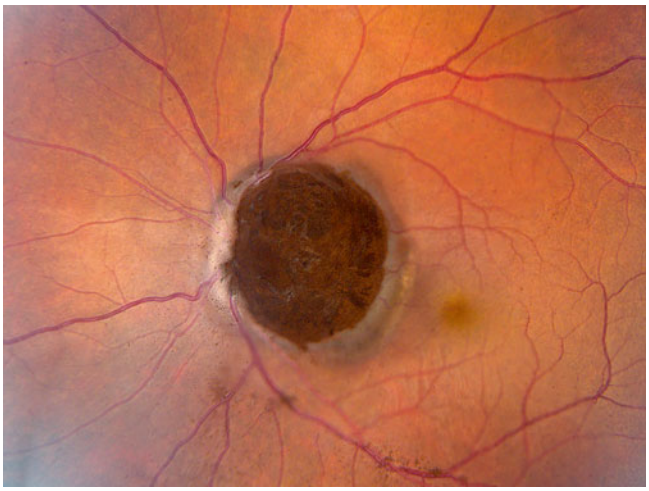

Fig. 49 Melanocytoma of the optic disc with minor vitreous seeding

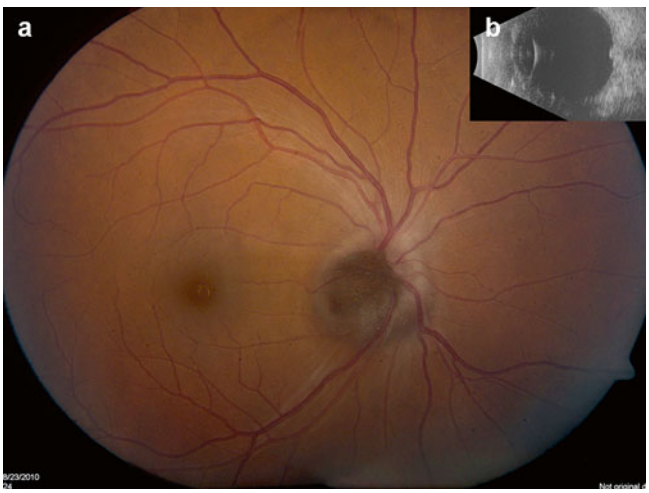

Fig. 50 Melanocytoma of the optic disc (**a**) appearing dense (**b**) on ultrasonography

Optic Disc Hemangioblastoma

Optic disc hemangioblastoma is a benign reddish mass of the disc, often with indiscrete margins that can produce subretinal fluid and exudation. Evaluation for von Hippel–Lindau disease is warranted. Management is challenging and includes laser photocoagulation, photodynamic therapy, plaque radiotherapy, external beam radiotherapy, or anti-VEGF medications (Fig. 51).

Optic Disc Metastasis

Optic disc metastasis appear as a yellow, pallid swelling of the disc with intrinsic vascularity, often in a patient with known cancer [37]. Typically, there are surrounding choroidal metastases. Management generally involves chemotherapy or ocular radiotherapy.

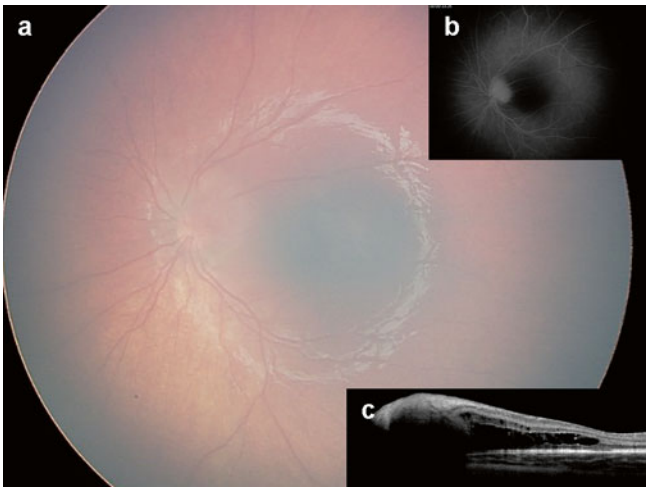

Fig. 51 Optic disc hemangioblastoma appearing as a subtle red mass along the superotemporal disc (**a**) with bright fluorescein angiographic enhancement (**b**) and evidence of subretinal and intraretinal fluid (**c**) on OCT

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