· 临床研究 ·

黄斑毛细血管扩张症炫彩眼底激光成像特征分析

孟祥娟[1]　谢肖[2]　关吉田[1]　王金艳[1]　孙晓蕾[1]　王红艳[1]　孟洁[1]　王颖[1]　刘婷婷[1]

[1]山东第一医科大学附属眼科医院(山东省眼科医院)　山东第一医科大学(山东省医学科学院)　山东省眼科研究所　山东省眼科学重点实验室-省部共建国家重点实验室培育基地　山东第一医科大学眼科学院,济南 250002;[2]山东中医药大学第一临床医学院,济南 250014

孟祥娟现在山东第一医科大学附属肿瘤医院,济南 250117

通信作者:刘婷婷,Email:tingtingliu@vip.sina.com

【摘要】　目的　观察黄斑毛细血管扩张症(MacTel)炫彩及多模式眼底影像特征。　**方法**　采用系列病例观察研究,分析 2019 年 1—11 月就诊于山东省眼科医院、经荧光素眼底血管造影(FFA)检查确诊为 MacTel 的患者 12 例 16 眼,其中 MacTel Ⅰ型 8 例 8 眼,男 4 例 4 眼,女 4 例 4 眼,平均年龄(62.3±12.5)岁;MacTel Ⅱ型 4 例 8 眼,均为女性,平均年龄(58.7±10.5)岁。所有受试者均行最佳矫正视力、裂隙灯显微镜、彩色眼底照相、炫彩眼底激光扫描成像、FFA、光相干断层扫描(OCT)及光相干断层扫描血管成像(OCTA)检查,观察不同类型 MacTel 特征。　**结果**　彩色眼底照相结果显示,MacTel Ⅰ型患眼中,6 眼黄斑区环形渗出合并水肿,1 眼黄斑水肿不伴硬性渗出,1 眼黄斑硬性渗出不伴水肿;MacTel Ⅱ型患眼中心凹颞侧视网膜透明度下降呈灰色。炫彩眼底激光扫描成像显示,MacTel Ⅰ型患眼黄斑渗出呈现点状黄色颗粒,黄斑水肿呈黄绿色,成像较彩色眼底照相清晰,蓝光及绿光反射图均见渗出的点状显影,且绿光反射图显影最强,蓝光显影次之,红外光显影最弱;MacTel Ⅱ型患眼黄斑颞侧呈绿色,成像较彩色眼底照相明显清晰,蓝光反射图显影最强,绿光显影次之,红外光显影最弱。在 OCT 检查中,MacTel Ⅰ型患眼表现为内层视网膜囊样水肿或外丛状层视网膜不均匀强反射信号;MacTel Ⅱ型患眼视网膜内外层结构缺失,空腔形成,其中 2 例出现外层视网膜萎缩等表现。在 OCTA 检查中,MacTel Ⅰ型和Ⅱ型患眼均表现为黄斑区浅层、深层毛细血管丛破坏,以深层毛细血管丛破坏更明显;MacTel Ⅱ型患眼血管间隙增大、血管密度降低、中心凹无血管区扩大更明显。在 FFA 检查中,MacTel Ⅰ型患眼表现为早期黄斑中心凹旁毛细血管充盈迟缓,颞侧血管扩张,部分呈瘤样扩张,后期瘤样扩张处局限性增强;MacTel Ⅱ型患眼表现为不同程度的早期黄斑中心凹旁小血管扩张,晚期黄斑区偏颞侧毛细血管呈弥漫性强荧光。　**结论**　炫彩眼底激光扫描成像技术能清晰地显示 MacTel 的形态特征,MacTel Ⅰ型与Ⅱ型影像特征差异明显。

【关键词】　视网膜毛细血管扩张症;多模式影像;光相干断层扫描血管成像;多波长炫彩图像

基金项目:山东省重点研发计划项目(2016GSF201088);山东省中医药科技发展计划项目(2015-150)

DOI:10.3760/cma.j.cn115989-20191210-00536

Multicolor scanning laser imaging in macular telangiectasia

Meng Xiangjuan[1], *Xie Xiao*[2], *Guan Jitian*[1], *Wang Jinyan*[1], *Sun Xiaolei*[1], *Wang Hongyan*[1], *Meng Jie*[1], *Wang Ying*[1], *Liu Tingting*[1]

[1]*Eye Hospital of Shandong First Medical University (Shandong Eye Hospital), State Key Laboratory Cultivation Base, Shandong Provincial Key Laboratory of Ophthalmology, Shandong Eye Institute, Shandong First Medical University & Shandong Academy of Medical Sciences, Jinan 250002, China;* [2]*The First Clinical Medical College, Shandong University of Traditional Chinese Medicine, Jinan 250014, China*

Meng Xiangjuan is now working at Cancer Hospital of Shandong First Medical University, Jinan 250117, China

Corresponding author: Liu Tingting, Email: tingtingliu@vip.sina.com

[**Abstract**] **Objective** To observe the characteristics of macular telangiectasia (MacTel) in multi-color and multi-mode fundus images. **Methods** An observational case series study was conducted. Sixteen eyes of 12 patients diagnosed with MacTel by fluorescein fundus angiography (FFA) from January to November 2019 in Shandong Eye Hospital were analyzed. There were 8 cases (8 eyes) with MacTel type Ⅰ, among which 4 cases were male and 4 cases were female, with an average age of (62.3±12.5) years. The other 4 cases (8 eyes) had MacTel type Ⅱ, all of which were female, with an average age of (58.7±10.5) years. Best corrected visual acuity, slit lamp microscopy, color fundus photography, multicolor scanning laser imaging, FFA, optical coherence tomography (OCT) and optical coherence tomography angiography (OCTA) were carried out in all the patients. This study adhered to the Declaration of Helsinki. The study protocol was approved by the Ethics Committee of Shandong Eye Institute (No. 2019S003). **Results** In color fundus images of MacTel type Ⅰ eyes, annular macular exudation with macular edema occurred in 6 eyes, macular edema without hard exudates in 1 eye, and hard macular exudates without macular edema in 1 eye. However, the transparency of retina in temporal fovea in MacTel type Ⅱ eyes decreased, showing a gray color. In multi-color fundus images of MacTel type Ⅰ eyes, punctate granular yellow macular exudation and yellow-green macular edema were observed, which were clearer than those in color fundus images. Punctate exudation was seen in both the blue and green reflectance images, which was clearest in green reflectance image, followed by blue reflectance image and then the infrared reflectance image. In OCT images of MacTel type Ⅰ eyes, cystoid edema of inner retina or uneven reflection signal of outer plexiform retina were observed. Loss of inner and outer retinal structures and cavities were observable in MacTel type Ⅱ eyes, and outer retinal atrophy appeared in 2 eyes. In OCTA images, the destruction of superficial and deep capillary plexus in macular area were observed in both MacTel type Ⅰ and type Ⅱ eyes, and the destruction of deep capillary plexus was more obvious. In addition, more obviously increased vascular space, decreased vessel density, and increased foveal avascular zone were found in MacTel type Ⅱ eyes. In early stage of FFA, delayed capillary filling near fovea was seen in MacTel type Ⅰ eyes, and dilated temporal vessels in fovea, some of which showed tumor-like dilation, and the limited tumor-like dilation was enhanced in the later stage. Different degrees of dilated parafoveal blood vessels in the early stage, and the capillary in the temporal side of the macula showing diffuse strong fluorescence in the late stage of FFA was observed in MacTel type Ⅱ eyes. **Conclusions** Multi-color scanning laser imaging can be used to observe the morphological characteristics of MacTel, and the imaging features of different types of MacTel are significantly different.

[**Key words**] Retinal telangiectasis; Multimodal imaging; Tomography, optical coherence/angiography; Multi-color image

Fund program: Shandong Key Research and Development Project (2016GSF201088); Shandong Province TCM Science and Technology Development Plan Project (2015-150)

DOI: 10.3760/cma.j.cn115989-20191210-00536

黄斑毛细血管扩张症(macular telangiectasia, MacTel)是以黄斑部周围毛细血管网扩张及视网膜神经上皮层萎缩为特征性改变的一类疾病,主要表现为视物变形、渐进性视力下降。早期研究提出了特发性中心凹旁视网膜毛细血管扩张的定义,并将其与 Coats 病相鉴别[1]。随着研究的不断深入,MacTel 被分成了 3 组 6 个亚型[2]。随后有研究提出一种简化的特发性 MacTel 分类方法,有 2 种不同的类型,Ⅰ型为动脉瘤性毛细血管扩张,Ⅱ型为中心凹周围的毛细血管扩张[3]。近几年,随着多种眼底影像检查技术的快速发展,光相干断层扫描(optical coherence tomography, OCT)和 OCT 血管成像(optical coherence tomography angiography, OCTA)被广泛应用于 MacTel 诊断中[4]。多波长炫彩眼底激光扫描成像技术应用 3 束激光同时分层扫描视网膜浅、中、深层结构,再通过叠加以及伪彩技术,可以分别获取到不同深度、不同层次的组织结构反射影像[4-6],能更直观地观察 MacTel 的影像。目前利用多波长炫彩眼底激光扫描成像技术分析 MacTel 临床特征的研究鲜有报道,分析其特征可以为 MacTel 诊断及分型提供依据。本研究拟分析不同分型 MacTel 的炫彩眼底激光扫描成像特征。

1　资料与方法

1.1　一般资料

采用系列病例观察研究方法,纳入 2019 年 1—11

月在山东省眼科医院确诊为 MacTel 的患者 12 例 16 眼，其中 MacTel Ⅰ型 8 例 8 眼，男 4 例 4 眼，女 4 例 4 眼，平均年龄（62.3±12.5）岁；MacTel Ⅱ型 4 例 8 眼，均为女性，平均年龄（58.7±10.5）岁。患者均主诉视力下降，伴或不伴视物变形。所有患眼眼压及眼前节检查均未见异常，MacTel Ⅰ型和Ⅱ型患眼最佳矫正视力（best corrected visual acuity，BCVA）分别为 0.05～0.7 和 0.2～0.8。参照文献[3,7]制定纳入和排除标准，纳入标准：（1）经荧光素眼底血管造影（fluorescein fundus angiography，FFA）以及 OCTA 确诊为 MacTel 者；（2）屈光介质透明，能够保证获得足够清晰的图像。排除标准：患有视网膜血管性疾病或炎症等其他眼底病变者。本研究遵循《赫尔辛基宣言》，研究方案经山东省眼科研究所伦理委员会批准（批文号：2019S003）。

1.2　方法

所有患者均行 BCVA 检查，并转换为最小分辨角对数视力，采用裂隙灯显微镜行眼前节检查；复方托吡卡胺滴眼液点眼扩瞳后采用传统光学眼底照相机（TRC-50DX，日本 Topcon 公司）行彩色眼底照相，并采用 Spectralis HRA+OCT 一体机（德国海德堡公司）分别行 FFA、频域 OCT（spectral domain OCT，SD-OCT）、OCTA 和炫彩眼底激光扫描成像检查。

1.2.1　彩色眼底照相　嘱受检者充分扩瞳后坐于眼底照相机仪器前，调整其头部位置，平视前方，拍摄彩色眼底照片并保存。

1.2.2　炫彩眼底照相　受检者扩瞳后取坐位，下巴置于颌托上，前额贴于横档处，嘱其注视目镜内蓝色十字光标，对准受检者的瞳孔，调整焦距至屏幕上出现清晰影像。为减少检查过程中受检眼的强光照射时间，首先采用 IR 模式追踪到受检眼黄斑区，再转换成炫彩模式，先检查健侧眼，再检查患眼。

1.2.3　OCT 检查　在 IR 模式下追踪到受检眼黄斑区，再转换成 OCT 模式获取黄斑区结构图像，扫描方式为多线扫，采集速度为 88 000 次/s，扫描区域为黄斑周围 15°×15°，共 49 条扫描线，每条扫描线间隔 120 μm。

1.2.4　OCTA 检查　在 IR 模式下追踪到受检眼黄斑区，转换成 OCTA 模式选择多线扫，采集速度为 68 000 次/s，扫描区域为黄斑周围 15°×15°，共 384 条扫描线，每条扫描线间隔 11 μm，观察黄斑区视网膜血流状况。

1.2.5　FFA 检查　先对受检者行荧光素钠变态反应试验，皮试阴性者给予质量分数 20% 荧光素钠 3 ml，5 s 内快速注入前臂肘正中静脉，注射开始时开启造影时间记录。FFA 检查时间为 15 min。

同一患者的影像检查均由同一医师于同一天内完成。若影像扫描位置、质量不符合要求，或存在过多运动伪迹，则再次进行检查，必要时手动分割视网膜结构。检查图片由 2 名经过专业培训的眼科医师进行诊断阅片及图片质量审查，当阅片医师之间出现结果不一致时，由第 3 名眼科医师审查并达成一致。

2　结果

2.1　MacTel 彩色眼底照相

MacTel Ⅰ型 6 眼眼底黄色脂质渗出边缘不清晰，黄斑水肿边界模糊，1 眼仅有黄斑水肿不伴黄斑硬性渗出，1 眼有黄斑区硬性渗出不伴水肿。MacTel Ⅱ型 8 眼黄斑区视网膜透明度下降呈灰色，以颞侧明显，部分区域可见细小的结晶样沉积物（图 1）。

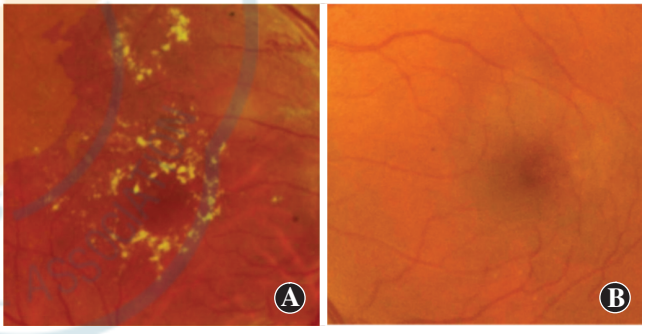

图 1　MacTel 患眼彩色眼底照相　A：MacTel Ⅰ型患眼黄斑水肿和环形渗出　B：MacTel Ⅱ型患眼黄斑偏颞侧透明度下降

Figure 1　Color fundus images of MacTel eyes　A: Macular edema and annular exudation was observed in a MacTel type Ⅰ eyes　B: The transparency of the temporal side of macula decreased in a MacTel type Ⅱ eyes

2.2　炫彩眼底激光扫描成像特征

MacTel Ⅰ型患眼黄斑水肿呈绿色，黄斑区渗出呈黄绿色颗粒样，边界清晰，绿光颗粒状显影较蓝光明显，红外光显影最弱（图 2）。MacTel Ⅱ型患眼黄斑区呈绿色高反射，以颞侧明显，蓝光显影最强，且可见点状高显影，绿光显影次之，红外光显影最弱（图 3）。

2.3　MacTel SD-OCT 特征

MacTel Ⅰ型 6 眼表现为内层视网膜囊样水肿合并外丛状层视网膜不均匀强反射信号，1 眼单纯表现为黄斑区外丛状层点状高反射，1 眼仅有黄斑水肿。MacTel Ⅱ型 3 眼视网膜内外层结构部分缺损，空腔形成，5 眼黄斑区外层结构消失，黄斑区萎缩（图 4）。

2.4　MacTel OCTA 特征

MacTel Ⅰ型患眼黄斑区浅层、深层毛细血管丛破坏，以深层毛细血管丛破坏更明显，环绕中心凹形成环形毛细血管扩张，可见瘤样扩张。MacTel Ⅱ型患眼黄斑颞侧毛细血管弥漫性扩张，浅层、深层血管丛破坏，血管间隙增大，血管密度明显降低，中心凹无血管区扩大，以深层血管丛变化最为明显（图 5）。

2.5　MacTel FFA 特征

MacTel Ⅰ型患眼 FFA 早期黄斑中心凹旁毛细血管充盈迟缓，颞侧血管呈扩张状态，部分呈瘤样扩张，FFA 后期瘤样扩张处局限性荧光增强。MacTel Ⅱ型患眼 FFA 早期表现为不同程度的黄斑中心凹旁小血管扩张，FFA 晚期黄斑区偏颞侧毛细血管呈弥漫性强荧光（图 6）。

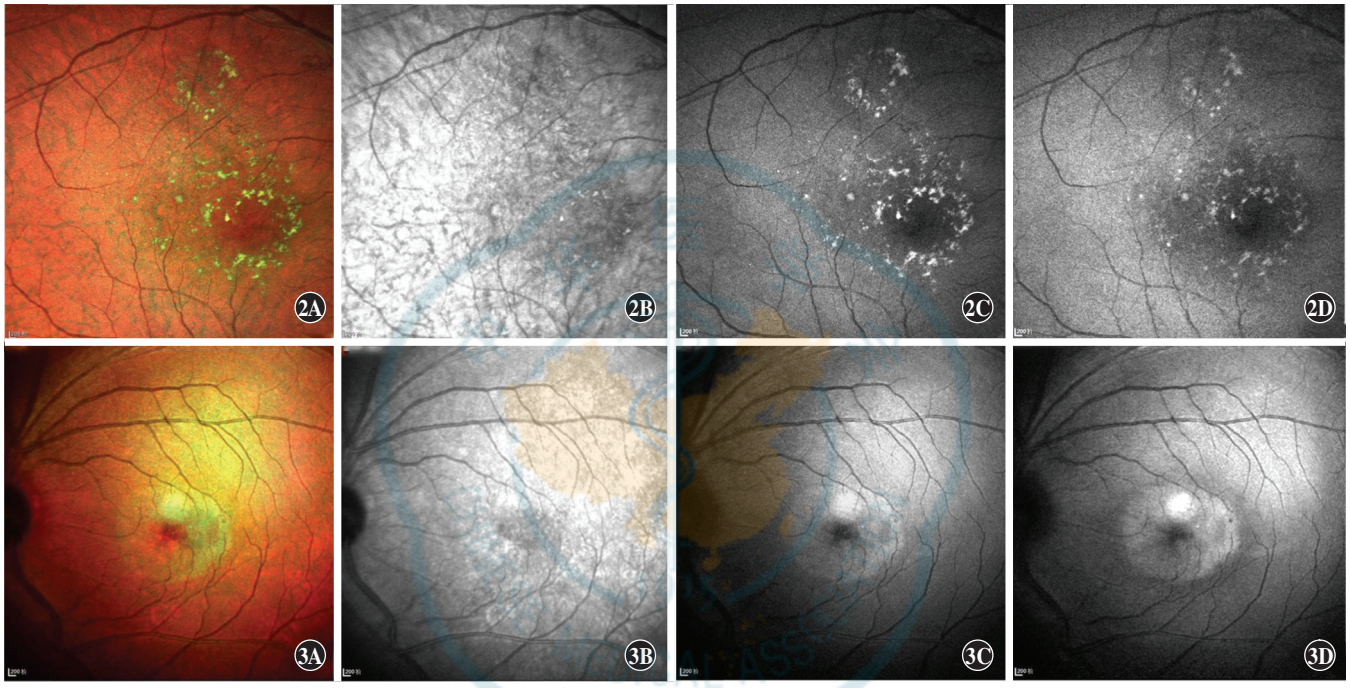

图 2　MacTel Ⅰ型患眼多波长炫彩眼底激光扫描成像　A：炫彩眼底图像显示黄斑区渗出表现为黄绿色颗粒样高反射　B：红外光图像可见较弱颗粒样显影　C：绿光图像可见较明显颗粒状显影　D：蓝光图像可见颗粒状显影，强度较绿光显影弱　**图 3　MacTel Ⅱ型患眼多波长炫彩眼底激光扫描成像**　A：炫彩眼底图像可见黄斑颞侧呈绿色高反射　B：红外光图像可见黄斑颞侧反射较弱　C：绿光图像显示黄斑区异常高反射　D：蓝光图像显示颞侧黄斑区明显异常高反射，较绿光图像明显

Figure 2　Multi-wavelength multi-color fundus images of MacTel type Ⅰ eyes　A: Granular yellow-green high reflection of macular exudation was seen in multi-color fundus image　B: Weak dot-like reflection was observed in infrared reflectance image　C: Strong dot-like reflection appeared in green reflectance image　D: Moderate dot-like reflection was displayed in blue reflectance image, which was weaker than that in green reflectance image

Figure 3　Multi-wavelength multi-color fundus images of MacTel type Ⅱ eyes　A: Green high reflection in temporal side of macular area was observed in multi-color images　B: Weak reflection in temporal side of macular area was seen in infrared reflectance image　C: Abnormal high reflection in macular area was shown in green reflectance image　D: Abnormal high reflection in temporal side of macular area was found in blue reflectance image, which was stronger than that in green reflectance image

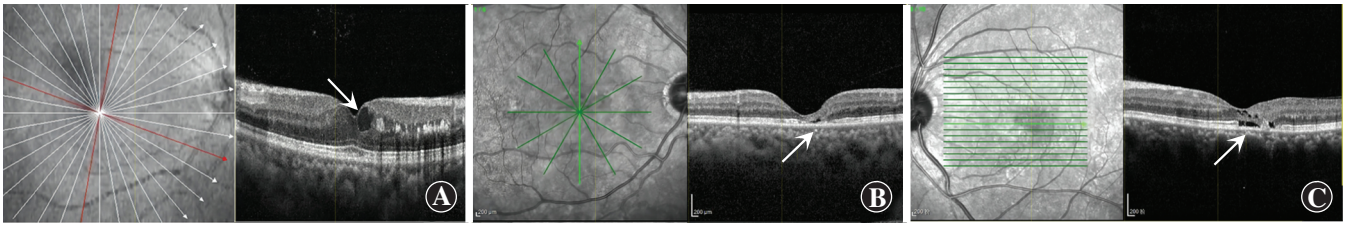

图 4　MacTel 患眼 SD-OCT 图像　A：MacTel Ⅰ型患眼黄斑区内层视网膜囊样低反射（箭头），神经上皮层间可见高反射信号　B：MacTel Ⅱ型患眼黄斑区外层视网膜萎缩，内层可见空腔（箭头）　C：MacTel Ⅱ型患眼黄斑区内外层结构均可见空腔（箭头）

Figure 4　SD-OCT images of MacTel eyes　A: Cystoid low reflection (arrow) in the inner retinal layer of macula was observed in the MacTel type Ⅰ eye, and high reflection was seen in the neuroepithelial layer　B: Outer retinal atrophy and inner retinal cavity (arrow) were seen in the macula of the MacTel type Ⅱ eye　C: Cavities (arrow) were observed in the outer and inner retina of the MacTel type Ⅱ eye

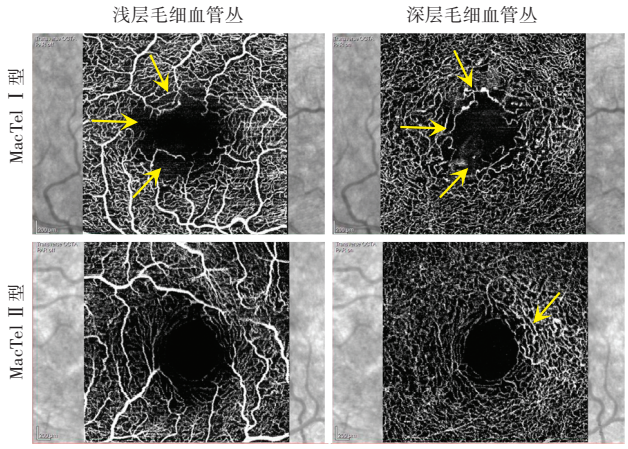

图 5　MacTel 患眼 OCTA 图像　MacTel Ⅰ型患眼黄斑区颞侧视网膜浅层和深层毛细血管丛破坏，可见瘤样扩张（箭头）；MacTel Ⅱ型患眼黄斑区颞侧视网膜浅层和深层毛细血管丛破坏，血管间隙增大，血管密度明显降低，深层毛细血管丛变化较浅层明显（箭头）

Figure 5　OCTA images of MacTel eyes　The superficial and deep capillary plexus of temporal retina in MacTel Ⅰ eyes showed destruction and tumor-like dilatation (arrow). Destruction of capillary plexus, increased gap between blood vessels and significantly decreased vessel density were observed in the superficial and the deep capillary plexus of temporal retina in MacTel Ⅱ eyes, and the changes were more obvious in deep capillary plexus (arrow)

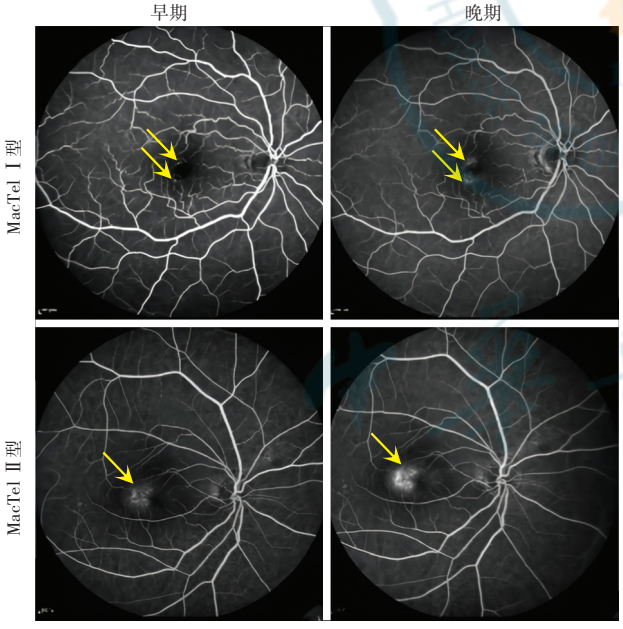

图 6　MacTel 患眼 FFA 图像　MacTel Ⅰ型患眼早期黄斑旁中心凹毛细血管充盈迟缓，部分血管瘤样扩张（箭头），晚期瘤样扩张处局限性增强（箭头）；MacTel Ⅱ型患眼早期黄斑中心凹旁小血管扩张（箭头），晚期黄斑颞侧毛细血管呈弥漫性强荧光（箭头）

Figure 6　FFA images of MacTel eyes　At the early stage of FFA in the MacTel type Ⅰ eye, the capillary filling of paramacular fovea was delayed, and some blood vessels showed tumor-like dilation (arrow), which was locally enhanced (arrow) at the late stage of FFA. At the early stage of FFA in the MacTel type Ⅱ eye, the small blood vessels near the fovea of macula were dilated (arrow). At the late stage of FFA, the temporal capillary of macula showed diffuse strong fluorescence (arrow)

3　讨论

根据对人群研究中眼底照片的评估，MacTel 患病率为 0.022%～0.1%[8]。然而，仅基于彩色眼底照相的诊断可能大大低估了真实的患病率，而炫彩眼底激光扫描成像及多模式影像学检查有助于清晰准确地发现早期疾病。MacTel Ⅰ型患眼彩色眼底照相可见黄斑水肿和/或渗出，炫彩眼底激光扫描成像中显示黄斑区水肿可呈绿色，渗出表现为黄绿色颗粒样高反射。MacTel Ⅱ型患眼彩色眼底照相示黄斑区视网膜透明度下降呈灰色，以颞侧明显，部分区域可见细小结晶样沉积物，而炫彩眼底图像可见黄斑颞侧清晰的绿色高反射。同时，多波长炫彩眼底激光扫描成像中绿光反射主要反映视网膜内层，包括内外丛状层和内核层；蓝光反射主要反映视网膜表面以及玻璃体与视网膜的接触组织[6]。本研究中 MacTel 的绿光和蓝光反射图像中阳性表现明显，表现为特征性旁中心凹高反射。炫彩眼底激光扫描成像较普通彩色眼底照相能更直观清晰地显示黄斑表面的形态变化，可大大降低误诊、漏诊的可能性。

本研究中 MacTel Ⅰ型患眼的 SD-OCT 表现为内层视网膜囊样水肿和/或外丛状层视网膜不均匀强反射信号，反射异常位置与炫彩眼底照相病灶位置一致。OCTA 可见黄斑区浅层、深层毛细血管丛破坏，以深层毛细血管丛破坏更明显，环绕中心凹形成环形毛细血管扩张，以瘤样扩张为特征。FFA 表现为早期黄斑中心凹旁毛细血管充盈迟缓，颞侧血管扩张，部分呈瘤样扩张，后期瘤样扩张处局限性增强，这与以往研究的描述一致[9]。MacTel Ⅱ型以双眼黄斑毛细血管网改变和神经上皮萎缩为特征，早期病灶局限在黄斑颞侧，后期发展为环绕黄斑中心凹[8-11]。本研究中 MacTel Ⅱ型患眼 SD-OCT 显示视网膜内外层结构缺失，空腔形成，其中 2 例出现外层视网膜萎缩等表现，与 Spaide[12] 研究结果一致；患眼未出现黄斑囊样水肿，与 Charbel Issa 等[13] 研究发现的 MacTel Ⅱ型患眼一般不出现黄斑囊样水肿结果相一致。OCTA 显示黄斑区浅层、深层毛细血管丛破坏，血管间隙增大，血管密度明显降低，同时本研究发现黄斑区血管向颞侧牵拉，且黄斑颞侧血管扭曲、扩张明显。

MacTel 的确切病理机制尚不明确，有研究显示Ⅰ型毛细血管扩张的原因是血-视网膜屏障功能性或结构性破坏，从而导致血管壁受损、动脉瘤形成或毛细血管扩张[8]。患眼眼底有轻微、斑片状无灌注区或毛细血管缺血和脂质沉积。而脂质多与毛细血管异常或

持续性、局灶性、较大的动脉瘤有关[3]。本研究通过炫彩眼底激光扫描成像发现视网膜表面为颗粒样黄绿反射，绿光的颗粒样显影明显强于蓝光反射及红外光反射，这与脂质渗出位于外丛状层的病理特征相吻合。

对于 MacTel Ⅱ型患眼，Powner 等[14-15]对 2 例 MacTel Ⅱ型患眼进行组织病理学研究，发现 MacTel Ⅱ型患眼的 Müller 细胞和光感受器丢失，推测 Müller 细胞功能障碍是 MacTel Ⅱ型的早期和可能的病理特征。Spaide[12]曾报道黄斑颞侧玻璃体视网膜的牵引力对黄斑周围组织的牵拉和直角转位静脉的形成起重要作用。本研究中颞侧蓝光显影明显增强，绿光显影次之，红外光未见明显异常，提示 MacTel Ⅱ型在玻璃体视网膜表面存在病变。

综上所述，多模式眼底影像的研究有助于更深层次、多角度了解 MacTel，为其早期诊断和鉴别诊断提供更多线索。多波长炫彩眼底激光扫描成像可作为 MacTel 检查的良好工具，其与传统彩色眼底照相相比，能更有效地呈现病灶细节，有助于早期筛查和发现黄斑旁毛细血管扩张的改变。本研究仍存在样本量小等局限性，未来需进一步扩大样本量进行验证。不同 MacTel 分型临床特征差异明显，提示玻璃体视网膜交界面和视网膜血管可能在不同 MacTel 类型发病机制中的作用不同，未来仍需进一步研究证实。

利益冲突　所有作者均声明不存在利益冲突

作者贡献声明　孟祥娟：参与研究设计、数据分析、论文撰写；谢肖、关吉田：采集和分析数据、论文修改；王金艳、孙晓蕾、王红艳、孟洁、王颖：采集和分析数据；刘婷婷：酝酿和设计试验、论文审阅及定稿

参考文献

[1] Gass JD. A fluorescein angiographic study of macular dysfunction secondary to retinal vascular disease. V. Retinal telangiectasis[J]. Arch Ophthalmol, 1968, 80(5): 592-605. DOI: 10.1001/archopht.1968.00980050594005.

[2] Chew E, Gillies M, Bird A. Macular telangiectasia: a simplified classification[J]. Arch Ophthalmol, 2006, 124(4): 573-574. DOI: 10.1001/archopht.124.4.573.

[3] Yannuzzi LA, Bardal AM, Freund KB, et al. Idiopathic macular telangiectasia. 2006[J]. Retina, 2012, 32 Suppl 1: 450-460. DOI: 10.1097/iae.0b013e31823f9a59.

[4] 杨景元，陈有信. 光相干断层扫描血管成像在眼底疾病诊断研究中的应用[J]. 中华实验眼科杂志，2017，35(10)：944-948. DOI: 10.3760/cma.j.issn.2095-0160.2017.10.020.
Yang JY, Chen YX. Application of optical coherence tomography angiography for diagnosis in fundus diseases[J]. Chin J Exp Ophthalmol, 2017, 35(10): 944-948. DOI: 10.3760/cma.j.issn.2095-0160.2017.10.020.

[5] Ben Moussa N, Georges A, Capuano V, et al. MultiColor imaging in the evaluation of geographic atrophy due to age-related macular degeneration[J]. Br J Ophthalmol, 2015, 99(6): 842-847. DOI: 10.1136/bjophthalmol-2014-305643.

[6] Pang CE, Freund KB. Ghost maculopathy: an artifact on near-infrared reflectance and multicolor imaging masquerading as chorioretinal pathology[J]. Am J Ophthalmol, 2014, 158(1): 171-178. DOI: 10.1016/j.ajo.2014.03.003.

[7] Engelbert M, Yannuzzi LA. Idiopathic macular telangiectasia type 2: the progressive vasculopathy[J]. Eur J Ophthalmol, 2013, 23(1): 1-6. DOI: 10.5301/ejo.5000163.

[8] Aung KZ, Wickremasinghe SS, Makeyeva G, et al. The prevalence estimates of macular telangiectasia type 2: the Melbourne Collaborative Cohort Study[J]. Retina, 2010, 30(3): 473-478. DOI: 10.1097/IAE.0b013e3181bd2c71.

[9] Chen YG, Chang YH. Multimodal imaging in the diagnosis of macular telangiectasia type 1[J/OL]. Asia Pac J Ophthalmol (Phila), 2022 (2022-02-07)[2022-07-26]. http://www.ncbi.nlm.nih.gov/pubmed/35131996. DOI: 10.1097/APO.0000000000000476. [published online ahead of print]

[10] Shinkai A, Saito W, Hashimoto Y, et al. Morphological features of macular telangiectasia type 2 in Japanese patients[J]. Graefe's Arch Clin Exp Ophthalmol, 2021, 259(5): 1179-1189. DOI: 10.1007/s00417-020-04989-x.

[11] Pauleikhoff L, Heeren T, Gliem M, et al. Fundus autofluorescence imaging in macular telangiectasia type 2: MacTel Study Report Number 9[J]. Am J Ophthalmol, 2021, 228: 27-34. DOI: 10.1016/j.ajo.2021.03.022.

[12] Spaide RF. Volume-rendered angiographic and structural optical coherence tomography[J]. Retina, 2015, 35(11): 2181-2187. DOI: 10.1097/IAE.0000000000000764.

[13] Charbel Issa P, Gillies MC, Chew EY, et al. Macular telangiectasia type 2[J]. Prog Retin Eye Res, 2013, 34: 49-77. DOI: 10.1016/j.preteyeres.2012.11.002.

[14] Powner MB, Gillies MC, Tretiach M, et al. Perifoveal müller cell depletion in a case of macular telangiectasia type 2[J]. Ophthalmology, 2010, 117(12): 2407-2416. DOI: 10.1016/j.ophtha.2010.04.001.

[15] Powner MB, Gillies MC, Zhu M, et al. Loss of Müller's cells and photoreceptors in macular telangiectasia type 2[J]. Ophthalmology, 2013, 120(11): 2344-2352. DOI: 10.1016/j.ophtha.2013.04.013.

（收稿日期：2021-09-27　修回日期：2022-07-31）

（本文编辑：张宇　骆世平）

广告目次