26 Myopic Traction Maculopathy: Guidelines to Treatment

Barbara Parolini, Michele Palmieri,
Alessandro Finzi, Gianluca Besozzi,
Angela Lucente, Ugo Nava, Sajish Pinackatt,
and Rino Frisina

Glossary and Terminology
We followed the definitions of retinoschisis suggested by Benhamou et al. [1]. We hereby provide the choices of glossary and terminology that were made in this study, in order to avoid any possible misinterpretation.

Schisis Splitting of the neurosensory retina. Since, in most cases, the schisis interested the whole macula and not just the fovea, and since it could be found not only in the fovea but also (or only) in the extrafoveal area (Fig. 26.1), we avoided the term Foveomacular schisis or Foveoschisis and selected to use maculoschisis.

Inner Maculoschisis Inner Maculoschisis (I-MS) is as a splitting of the inner retinal layers, at different levels, from the internal limiting membrane (ILM) to the inner nuclear layer (Fig. 26.2). The ILM can be detached from the nerve fibers layer and connected to it with a column-like structure.

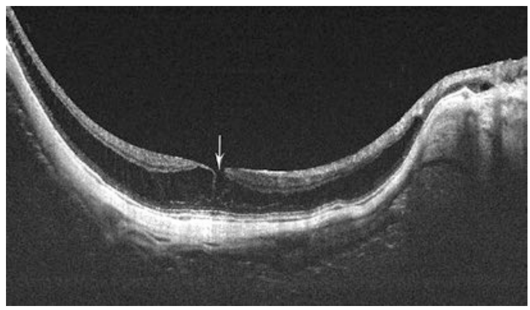

Fig. 26.1 Eye affected by outer maculoschisis involving the whole macula in a 49-year-old female. The arrow indicates an associated inner lamellar macular hole

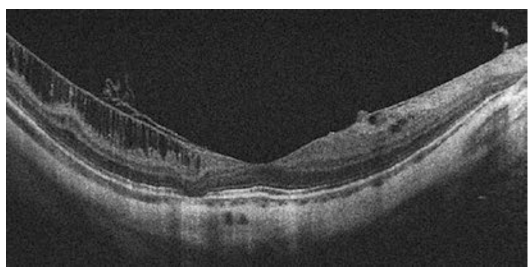

Fig. 26.2 Eye affected by inner maculoschisis in a 44-year-old female

Outer Maculoschisis Outer Maculoschisis (O-MS) is a splitting of the outer retinal layers (Fig. 26.1), from the outer plexiform layer, that changes in a column like structure, to the outer nuclear layer to the external limiting membrane and the photoreceptors layer.

B. Parolini (✉) · M. Palmieri · A. Lucente · U. Nava
Eyecare Clinic, Brescia, Italy

A. Finzi · S. Pinackatt
Department of Ophthalmology, Istituto Clinico S. Anna, Brescia, Italy

G. Besozzi
Department of Ophthalmology, Vito Fazzi Hospital, Lecce, Italy

R. Frisina
Department of Ophthalmology, University of Padova, Padova, Italy

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Inner Lamellar macular hole Inner Lamellar Macular Hole (I-LMH) is a splitting of the foveal layers, developing from the internal limiting membrane (Fig. 26.1). The depth and width of the I-LMH may vary significantly.

Outer Lamellar Macular Hole Splitting in the layer of the photoreceptors (Figs. 26.3 and 26.4). The location and the width of the Outer Lamellar Macular Hole (O-LMH) may vary significantly.

Macular detachment We defined macular detachment (MD) as cases with neurosensory detachment (Fig. 26.4) with separation of the photoreceptors from the retinal pigment epithelium (RPE).

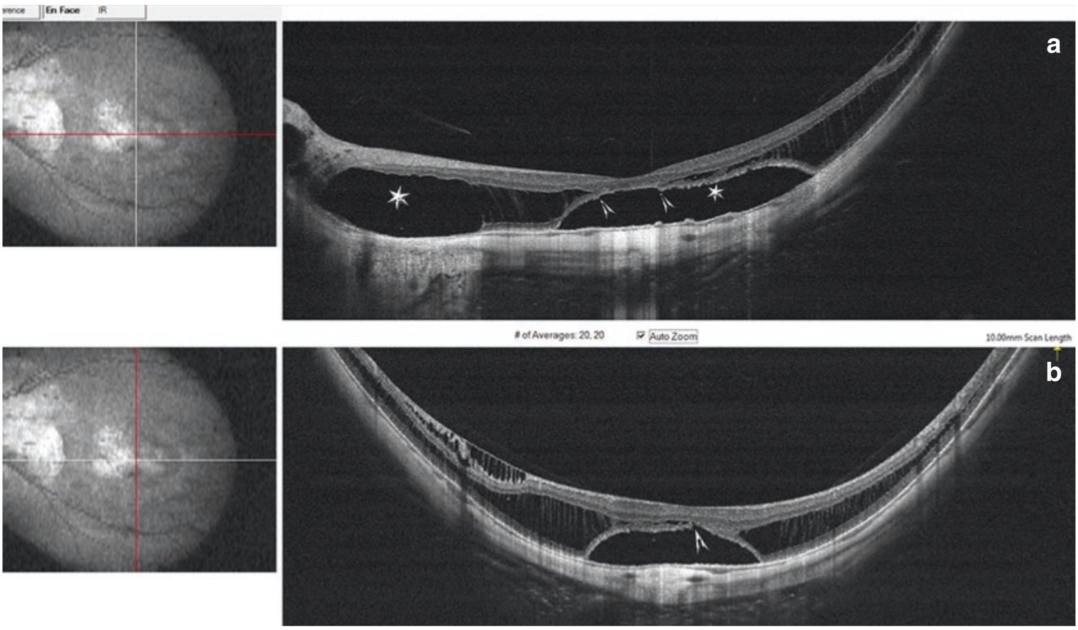


Fig. 26.3 Eye affected by inner and outer maculoschisis and by foveal detachment in a 59-year–old female. The arrow indicates an associated outer lamellar macular hole. The star indicates the areas of detachment. (**a**) horizontal scan, (**b**) vertical scan

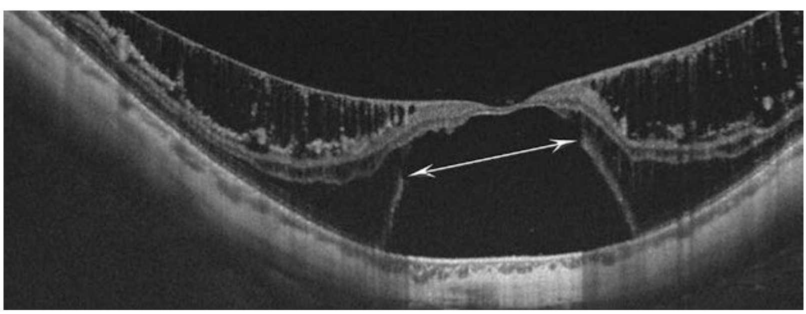


Fig. 26.4 Eye affected by inner and outer maculoschisis and by foveal detachment in a 62-year-old male. The arrow indicates the extension of an associated outer lamellar macular hole

26.1 Definition

Myopic Traction Maculopathy is a complex disease that affects high myopic eyes with and without posterior staphyloma. Despite different studies have been published, there is no agreement on the definition, neither a complete knowledge of the natural history and the pathogenesis, nor a unique classification of the disease. Moreover, the surgical treatment is still controversial.

In literature, different definitions of MTM may be found, from macular schisis-like thickening of the retina, to foveal detachment, to macular foveoschisis (MF), to foveoschisis, to shallow macular detachment.

The first description of MTM was given by Phillips in 1958 [2], who reported a posterior retinal detachment, without macular hole in patients with myopic staphyloma, assuming a tractional pathogenesis of what they called "retinomacular schisis."

In 1999, Takano and Kishi first published the optical coherence tomography (OCT) characteristics and findings of "foveal retinomacular schisis" [3].

Panozzo et al. [4] first described this condition as "myopic traction maculopathy" (MTM) and established that MTM may affect patients with high myopia and posterior staphyloma in 9–34% [4].

Shimada et al. [5] described different stages of the MF, leading to a foveal detachment, through the formation of an outer lamellar hole.

Recently the authors have proposed a new classification of MTM and defined MTM as a progressive disease that first involves the innermost layers of the retina with an Inner Macular Schisis (I-MS) and gradually progresses involving the outermost retinal layers until a macular detachment appears, while the schisis disappear. The MTM Staging System has been published [6].

26.2 Epidemiology

MTM is thought to affect 9% of high myopic eyes [7]. About 50% of patients affected progresses to major complications such as Full-thickness macular hole (FTMH) or macular detachment within 2 years [8].

Panozzo et al. reported that 9–34% of high myopic eyes with posterior staphyloma may be affected by MTM [4].

26.3 Pathogenesis: The Game of Forces

The pathogenesis of MTM is multifactorial and it is still not fully understood. The rigidity of ILM, the progression of the staphyloma and the antero-posterior traction caused by epiretinal affections seem to contribute to the evolution of MTM.

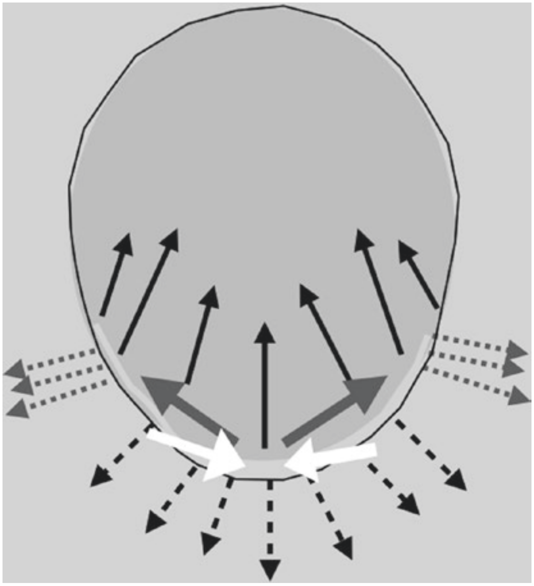
Anatomically, the retina is a multilayered multicellular structure which is held together, as a unique tissue, by *tangential centripetal* forces, mainly exerted by the Muller cells and by the external and internal limiting membranes.

In progressive myopia, different *centrifugal* forces tend to modify the shape and the location of the retina and the fovea from the ideal one, racing against the unique centripetal intraretinal force. These centrifugal forces may be exerted by the vitreous and the sclera, with two main different directions: tangential or perpendicular to the retinal tissue.

The progressive deformation of the sclera due to staphyloma induces an increasing stretching of the choroid–RPE–retina complex toward lateral and posterior orbit. The vitreous, as well as the sclera, may also generate both tangential and perpendicular centrifugal force; the latter toward the vitreous cavity.

This "Game Of Traction" leads to different clinical pictures and to a combination of inner maculoschisis, outer maculoschisis, inner LMH, outer LMH, foveal to macular detachment, macular detachment with a FTMH, FTMH on flat retina. Figure 26.5 describes the interaction of the different forces exerted on the retina in progressive myopia.

Early stages of MTM seem to involve first the innermost retinal layers and presenting as an I-MS. Then the progression of the disease depends on the prevalent centrifugal forces exerted on the retina.



arrow color	type of force	direction of vector	exerted by	action
white	centri petal	to the fovea	intraretinal structure	holds the retina together
line black	centri fugal	to the anterior vitreous	vitreous	pull the retina anteriorly
dark grey	centri fugal	to the lateral orbit	vitreous	stretch and open the fovea
dotted grey	centri fugal	to the lateral orbit	lateral sclera	stretch and open the fovea
dashed black	centri fugal	to the posterior orbit	posterior sclera	pull the retina posteriorly

Fig. 26.5 Schematic representation of the different forces exerted on the retina in an eye with pathologic myopia. One centripetal force (white) maintains the shape and attachment of the retina. Different centrifugal forces tend to detach or stretch the retina

If the prevalent centrifugal forces are perpendicular (Fig. 26.6), I-MS progresses and involves the outer layers becoming an IO-MS, then an O-MS until an MD appears. While the outer component further progresses to MD, the inner component of schisis is progressively relieved, because the intraretinal force becomes progressively prevalent when the retina detaches from the RPE.

Once the macula is detached, a disruption and splitting of the ellipsoid zone band might occur generating an O-LMH.

On the other hand, if the prevalent centrifugal forces are tangential, the patient will develop an I-LMH and eventually a FTMH (Fig. 26.7). The delamination of the retinal layers can be asymmetric in the different macular quadrants and the I-LMH may show different shapes based on the direction of the main vector of traction. The observation that a myopic LMH evolves into an FTMH was already made [9, 10].

When both the perpendicular and the tangential forces act together, a macular detachment with either lamellar (Fig. 26.8a, b) or FTMH (Fig. 26.8b, c) will appear.

Epiretinal abnormalities such as epiretinal membranes or vitreoretinal tractions from anomalous adhesion between vitreous cortes and retina, may also be associated with to every manifestation of MTM and contribute to the disease progression.

The natural course is not completely well-known due to the limited number of studies about it. Some patients remain stable for a year while others progress. MTM spontaneous resolution has been reported. However, it seems clear that the progressive nature of the disease is a consequence of its pathogenesis [11]. The Authors have observed cases of spontaneous resolution that restarted to progress years after the resolution (REF).

26.4 Clinical Manifestations and Diagnosis

The onset of MTM may vary among patients and may be totally asymptomatic in early stages [12, 13].

As a consequence of the lack of symptoms, the knowledge of the natural history is not easily

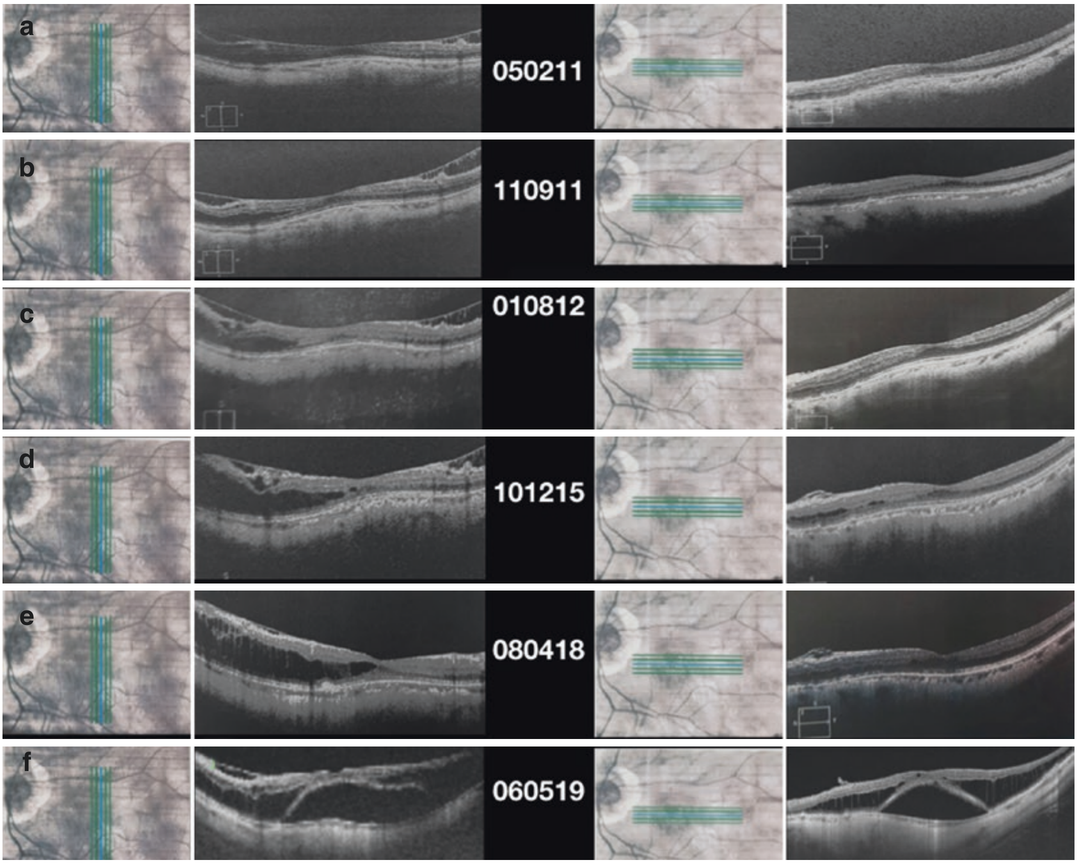


Fig. 26.6 Natural evolution of MTM with prevalent forces perpendicular to the retina in a female patient. (**a**) OCT taken at the age of 43 years on February 5, 2011, showing MTM in the form of inner-outer schisis and normal fovea. BCVA was 0.8 Decimal. (**b**) OCT taken at the age of 43 years on September 11, 2011, showing MTM in the form of inner-outer schisis and normal fovea. BCVA was 0.8 Decimal. (**c**) OCT taken at the age of 44, on August 1, 2012, showing MTM in the form of predominantly outer schisis and normal fovea. BCVA was 0.7 Decimal. (**d**) OCT taken at the age of 47 years, showing MTM in the form of inner-outer schisis. BCVA was 0.7 Decimal. (**e**) OCT taken at the age of 50 years, showing MTM in the form of predominantly outer schisis. The inner component of the schisis is less apparent. The schisis is visible only in the area where the concavity of the sclera is more evident and pronounced. BCVA was 0.7 Decimal. (**f**) OCT taken at the age of 51 years, showing MTM in the form of schisis detachment with normal fovea. BCVA was 0.2 Decimal

predictable [14] and the disease could be underestimated. The symptoms reported by patients are blurred vision, reduce visual acuity, central scotoma, and, more rarely, metamorphopsia [4].

Indirect ophthalmoscopy and biomicroscopy are limited in detecting signs of MTM, because of the retinal transparency and the chorioretinal changes [3]. However, typical changes of progressive myopia may be revealed: chorioretinal atrophy, peripapillary atrophy, staphyloma, lacquer cracks, and myopic CNV.

OCT is the key instrument to diagnose this disease [15]. However, the OCT 2D B-scan has limitations. This is demonstrated by the fact that the vertical and horizontal scans of these eyes can be completely different (Fig. 26.4). We should imagine the posterior pole of the eye with progressive myopia as a three-dimensional concave structure, with an inner side, consisting of the vitreous cavity, and an outer side consisting of the sclera. Thus, combining a 3D MRI with OCT reconstruction better images the posterior pole of

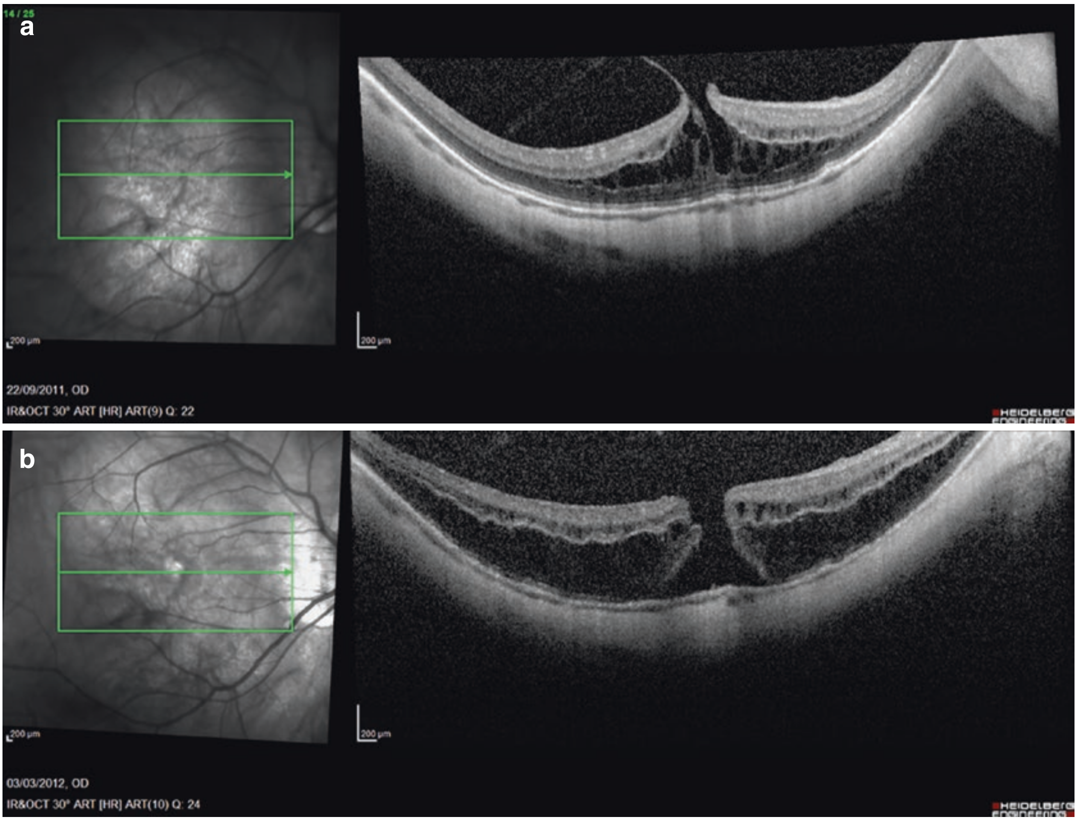


Fig. 26.7 Example of natural progression of MTM due to tangential forces. (**a**) OCT taken at the age of 42 years, showing an O-MS and an I-LMH with VMT. (**b**) 3 years later, the OCT shows a progression to an FTMH with predominantly O-MS and no evident epiretinal abnormalities

myopic eyes and it is more appropriate to study MTM (Fig. 26.9).

Maculoschisis is a separation of the inner plexiform layer or at the inner limiting membrane or of the outer retinal layers, between the outer plexiform and the outer nuclear layer [1, 16]. The splitting of retinal layers appears as highly reflective multiple columnar vertical or vertical oblique structures, with a hyporeflective space between these structures [1]. It is easily distinguishable from cystic spaces which are hyporeflective but rounded or oval.

Posterior retinal detachment or, according to other definitions foveal detachment, can be another common aspect of MTM [11]. Foveal detachment is a separation between the RPE and the photoreceptors layers [13, 17], usually limited to the posterior pole, and may be associated with an FTMH. Many authors confirm that foveal detachment occurs after the formation of the MF and may precede the formation of a macular hole [18].

OCT might also show the presence of an outer lamellar hole (O-LMH) as a disruption of the ellipsoid zone band on a detached fovea. The O-LMH represents a real splitting in the photoreceptors and is visible in the area of foveal detachment. Defects in the photoreceptors inner and outer segments may contribute to visual loss associated with MTM and may have predictive value for postoperative visual recovery [19].

The use of microperimetry should also be considered to analyze foveal functionality [20].

Epimacular abnormalities may usually be detected as the hyper-reflective lines overlying the inner macular schisis and seem to be important contributors to the separation of the inner layers of the neural retina which in turn leads to macular schisis [16].

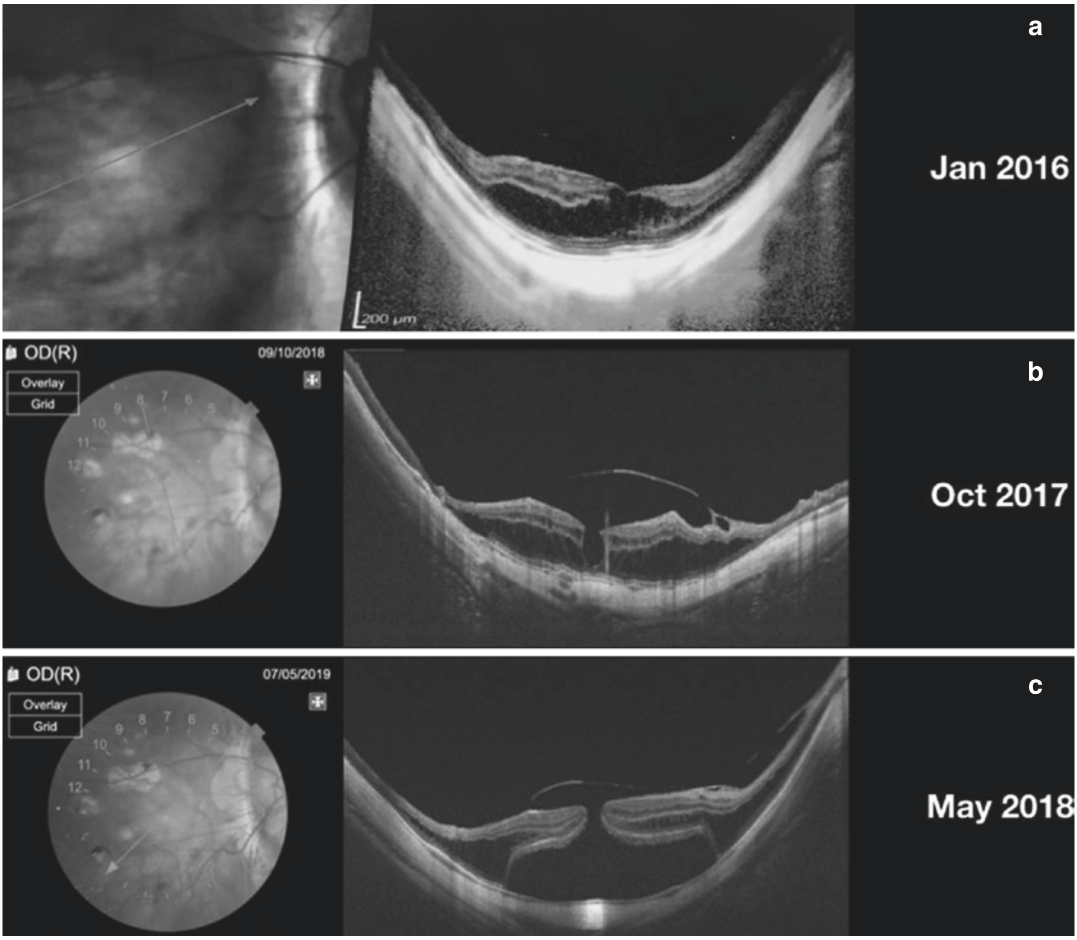


Fig. 26.8 Evolution of MTM in a highly myopic eye of a female. (**a**) OCT scan, taken at the age of 53 years, shows O-MS in the macula with normal fovea. (**b**) OCT scan, taken at the age of 55 years, shows O-MS in the macula with the development of an I-LMH and visible epiretinal abnormalities. (**c**) OCT scan, taken 6 months after the previous one, shows O-MS with development of macular detachment and FTMH

26.5 Management

One of the most critical aspects of MTM is management.

The current approach to MTM is to follow-up patients and surgery is recommended in case of serious visual impairment and evolved macular detachment with macular holes. This management limits the functional outcomes of surgery.

Asymptomatic patients should be followed with observation every 12–18 months, since BCVA in this group is still good and the progression is slow. However, patients suffering a vision loss or a worsening of metamorphopsia, patients affected by a symptomatic I-LMH or a FTMH and patients affected by macular detachment should be directed to surgery.

26.5.1 Surgical Approach

The first surgical approaches to MTM were directed to solve the most severe and final stage of MTM, the retinal detachment associated with a macular hole. The aims of these interventions were to restore anatomy and did not guarantee an acceptable functional recovery.

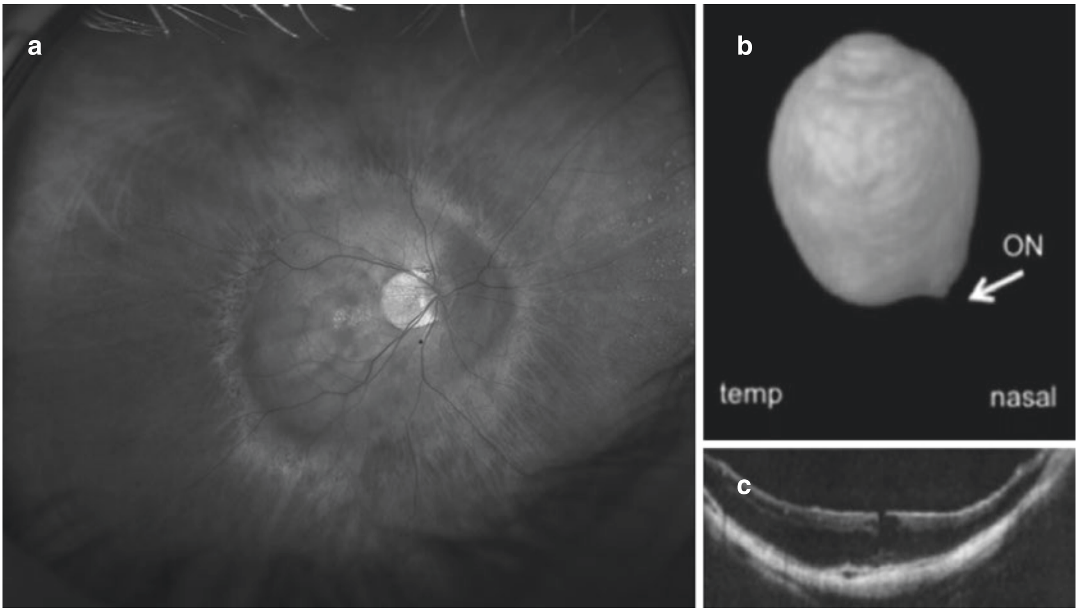


Fig. 26.9 Eye affected by outer maculoschisis. (**a**) Wide field IR image showing a Type 1 Staphyloma involving the posterior pole. (**b**) MRI imaging showing the whole shape of the eyeball. The white arrow indicates the Optic Nerve (ON). (**c**) OCT scan showing the predominantly outer schisis associated with an I-LMH

The idea of preventing axial elongation and scleral growth by the placement of material over the posterior part of the eye was proposed by surgeons many years before the description of MTM. Shevelev [21] first proposed, in 1930, the transplantation of fascia lata for scleral reinforcement.

In 1957, Schepens Okamura and Brockhurst described the macular buckling procedures [22].

From 1957 to the 1980s, the gold standard for the treatment of macular detachment with macular hole was definitely the macular buckle (MB) [22–31].

The first article that considered pars plana vitrectomy (PPV) for the Macular Hole Macular Detachment (MHMD) goes back to 1982 [32] by Gonvers. Many authors published afterward [33, 34]. Since then, PPV has been proposed as the intervention of choice, with the rationale of eliminating the tangential tractions, allowing the retina to relax. Therefore, MB was abandoned for a while, mainly due to the challenges and complications linked to the surgical technique.

However, PPV had limited efficacy. Indirectly this lack of success was revealed by the list of papers proposing different approaches with different tamponades. PPV with gas was linked to a high rate of failure or relapse. In 1999, Wolfensberger et al. [35] proposed the use of silicone oil associated with the laser treatment of the hole and obtained 92% of retinal reattachment, but, as expected, poor increase in vision.

The increasing use of peeling the ILM improved the range of success of PPV, as demonstrated in 2001 by Kadonoso et al. [36].

Thereafter, Lu et al. [37] in 2002, compared various methods of PPV, associating the injection of gas, with and without laser treatment of the macular hole, and injection of silicone oil without laser treatment, demonstrating the superiority of the first method, with the results of 93%, 58%, 57%, respectively, giving a key role to laser treatment for anatomic success. It must be highlighted, however, that functional results were very poor.

In 2006, Chen [38] reported a retinal reattachment success rate of 50–60% after PPV and gas injection.

Panozzo et al. [15], in 2007, carried out the first large-scale work on MTM. The study consisted of 24 eyes (including 5 with foveal detachment and 19 with MF), followed for 5 years, and treated with the sole purpose of removing the vitreous-retinal traction without using tamponade. The authors reported that 95.8% of the eyes had complete resolution of MTM stable in time. Four of the 5 eyes with macular detachment and 1 eye with maculoschisis developed, however, a macular hole that did not hesitated in a new macular detachment and an eye remained unchanged. As for the visual recovery, 70% improved, 30% remained unchanged.

Different authors [39, 40] presented promising results with the use of heavy silicone oil in the treatment of eyes with persistence of idiopathic macular hole after PPV and gas injection. However, after removal of heavy silicone oil, retinal detachment was reported.

In 2011, Mete et al. [41] compared the results of standard silicone oil 1000 cSt and heavy silicone oil in the ability of reattach the retina and closing the hole in 42 cases of MHMD. The anatomic results were similar, with a macular reattachment rate of 76.5% and 81.8% for silicone oil and for heavy silicone oil, respectively. The frequent relapses of macular detachment in both groups were always linked to reopening of the hole. Mete et al. concluded that there was a high recurrence rate of retinal detachment and an unsatisfactory final BCVA with both tamponades.

The success of PPV in high myopia remained limited with any tamponade, mainly because of high rate of retinal detachment recurrence, failure to close the hole in MHMD, and risk to induce an iatrogenic macular hole in MTM.

The unsatisfactory results of PPV left open the way to a new course of publications on buckling the macula, which started again, after 20 years, in 2000 with Sasoh [42].

In 2001 Ripandelli [43], and later in 2005 Theodassiadis [44], described MB success with a sponge and with a solid silicone exoplant, respectively. Although the reattachment rate with macular buckling was reported to be very high, the rate of hole closure was unknown because of lack of study with OCT.

The point was that surgeons dealing with MHMD realized the limitation of PPV. However, MB, although more efficient, remained difficult and linked to complications.

Some authors started to find a way to make the macular buckling technique easier, first of all with different buckle designs.

Tanaka, Ando, and Usui [45] published in 2005 the successful approach of a new semirigid rod-exoplant in MHMD recurrences after PPV. The exoplant consisted of a T-shaped semirigid silicone rubber rod internally reinforced with titanium wires and an indenting head at one end.

In 2009, Parolini presented the 2 years results of a new design of MB, at the Heatam meeting in Amsterdam. The idea was to propose an L-shaped buckle, made with a titanium stent inserted into a silicone sleeve, with the aim to obtain a macular indentation but allowing an anterior suture. The shape resembled the Ando plomb with the difference of using a titanium stent (MRI compatible), not stainless steel wire, and soft silicone sponge, not solid silicone, to indent the macula.

In 2009, B. Ward et al. [46] examined the buckling of the posterior pole, with sclera reinforcement, as a tool for myopia control and followed the course of untreated fellow eyes. Ward concluded that the experience with 59 cases showed effective axial myopia control and an acceptable safety profile for posterior pole buckling. No case of visual acuity loss occurred with the procedure.

In 2012, Tian J et al. [47] applied the technique of macular buckling in 5 cases of MHMD after initial failure of pars plana PPV with ILM peeling and silicone oil tamponade. In this study, the retina was reattached after buckling. However, visual acuity did not improve and anatomical macular holes only closed in two patients. This could be related to extensive and long term and marked atrophy of the RPE/choriocapillaris complex in the macular area.

More recent literature [48, 49] added to PPV the technique of inverted ILM flaps reporting a higher success rate to close the holes [50].

Alkabes [51] recently published a 16-year review on MB for MTM and compared the results with PPV. She clearly confirms that MB was the first technique considered to treat MHMD.

26.5.2 Guidelines to MTM Treatment

The surgical treatment of MTM is still controversial. The goals of surgery need to be anatomical and functional. The anatomical goals should be retinal attachment; hole closure; atrophy prevention. The functional goals should be to improve or maintain central vision and the central visual field. However, in eyes with progressive myopia we should ideally aim not only to treat but also to prevent the outset or the progression of MTM, since progressive myopia is a degenerative and progressive disease.

The authors have proposed new management guidelines of MTM, based on the new MTM Staging System (MSS).

The aim of their study was to clarify how to choose among four options of management: observation, PPV, MB, or combined surgery (MB + PPV).

The choice of treatment was made by looking at the forces exerted on the retina (Fig. 26.5), with the intention to counteract the centrifugal forces that tend to detach the retina from the eyewall, perpendicularly, and/or tend to split the retina, tangentially, in the macula. In their study, the authors used PPV, MB, or combined surgery to treat 157 eyes affected by different stages of MTM.

Observing the anatomical results of the different treatments, they concluded that PPV better addressed the tangential tractions on the inner retinal surface, i.e., the modulation of the macular pattern, while the MB addressed the perpendicular tractions on the retina induced by scleral elongation, i.e., the modulation of the retinal pattern.

Treating a prevalent tangential traction with a MB brings to potential complications as well as treating a prevalent perpendicular traction with PPV. If only one component of traction is treated, the opposite component will manifest itself in time. Thus, whenever a combination of perpendicular and tangential forces is treated only with a MB, the perpendicular component is solved and the retinal pattern will improve, but the tangential force inducing alteration of the macular pattern remains unchanged and might even worsen.

For example, if a patient affected by a mild maculoschisis, with mild ERM and without preoperative I-LMH undergoes MB, the tangential tractions induced by the buckle, pushing the retina vertically and anteriorly, lead to a iatrogenic splitting of the fovea (Fig. 26.10).

In the same way, when O-MS or a foveal detachment are treated only with PPV (Fig. 26.11) the schisis and detachment have a low chance to resolve or end up in iatrogenic macular hole.

Parolini assessed that inner and outer schisis should be followed with observation every 12–18 months, since BCVA in these groups is still good and the progression is slow, unless epiretinal abnormalities are associated. The symptomatic cases should be treated as cases of ERM without MTM. A high rate of anatomical success could be reached when PPV was used for schisis associated with lamellar of full-thickness macular hole.

MB should be considered and evaluated case by case when outer schisis is associated with a macular hole. MB and late PPV revealed particularly useful in cases of maculoschisis and lamellar macular hole, even in eyes with macular atrophy, obtaining a gain in visual function when the schisis and the I-LMH were resolved.

The recommendation by the author is to treat the schisis/detachment first, with MB, and then to treat the macular pattern with PPV, only if required by lack of recovery of visual acuity or by progression of the I-LMH.

The final anatomical resolution of the schisis is slower with MB alone, compared with combined MB + PPV.

The final restoration of the foveal profile in the presence of lamellar of FTMH was achievable only when PPV was added. However, even in these cases, PPV can be added at a later time only if needed, thus avoiding the possible side effects of PPV and restoring the foveal profile on an attached retina not affected by schisis nor detachment.

Macular detachments should be treated immediately with an MB alone. PPV might be added later on and only if needed.

Macular detachments associated with a macular hole (MHMD) should be immediately treated

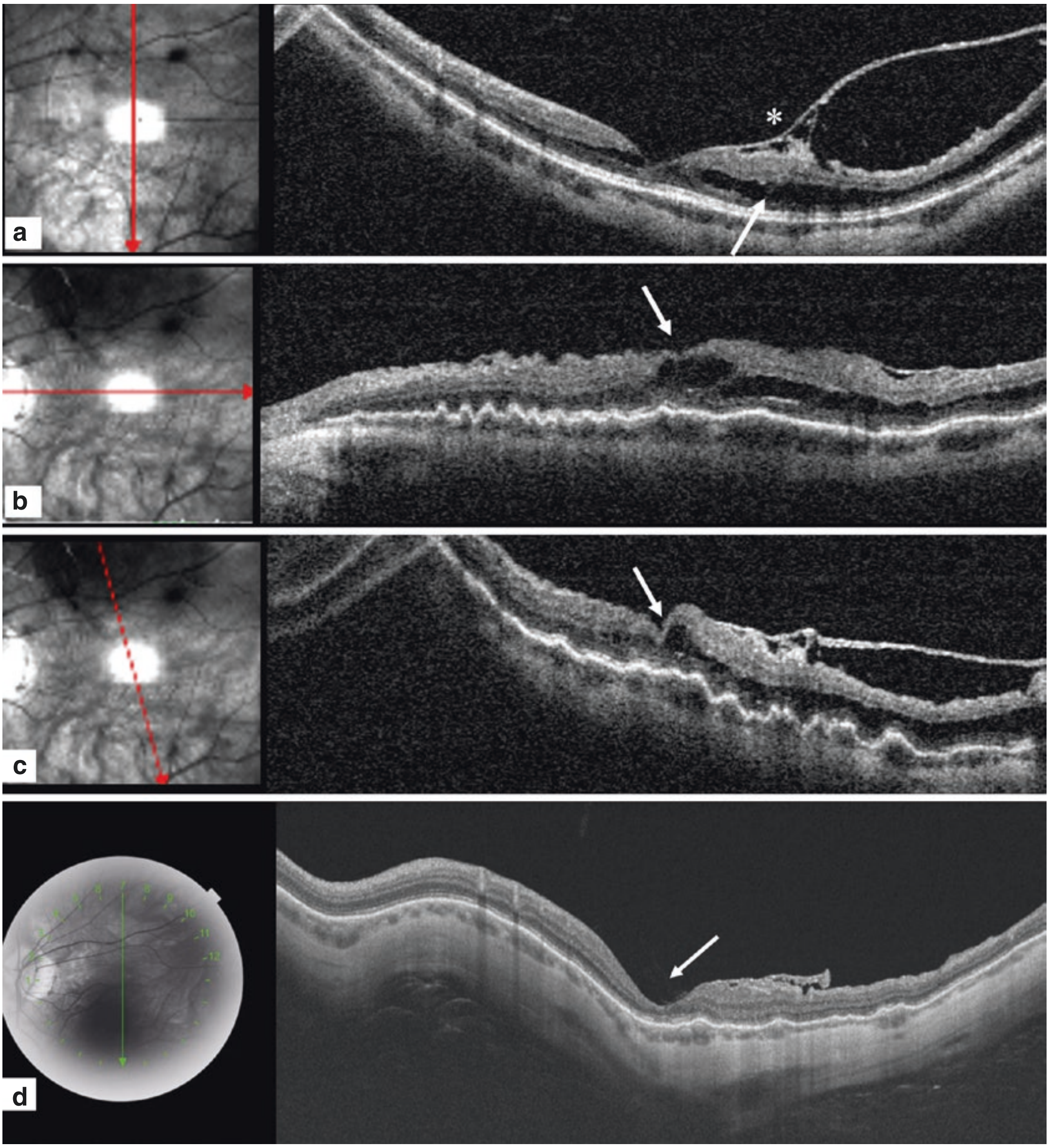


Fig. 26.10 Eye affected by outer maculoschisis with epiretinal abnormalities in a 45-year-old male. (**a**) Preoperative OCT showing the schisis (white arrow) and epiretinal abnormalities (star). (**b**) Horizontal OCT scan 2 months after MB, showing the worsening of the maculoschisis (white arrow). (**c**) Vertical OCT scan 2 months after MB, showing the worsening of the maculoschisis (white arrow) and a more evident traction with different vectors of the epiretinal abnormality. (**d**) Vertical OCT scan 12 months after MB showing resolution of the schisis (white arrow)

with combined MB + PPV in order to treat simultaneously the outer retina and the macular hole.

Both MB and combined surgery resolve the schisis. While the result of buckle is slow, progressive, and visible in months, the result of subsequent or combined PPV is visible within 1–2 weeks. The surgeon should choose, case by case, whether a quick result is better than a slow result, which allows to avoid the consequences of PPV.

Some cases of MHMD, were initially treated successfully only with MB and gas injection, obtaining both the retinal attachment and the

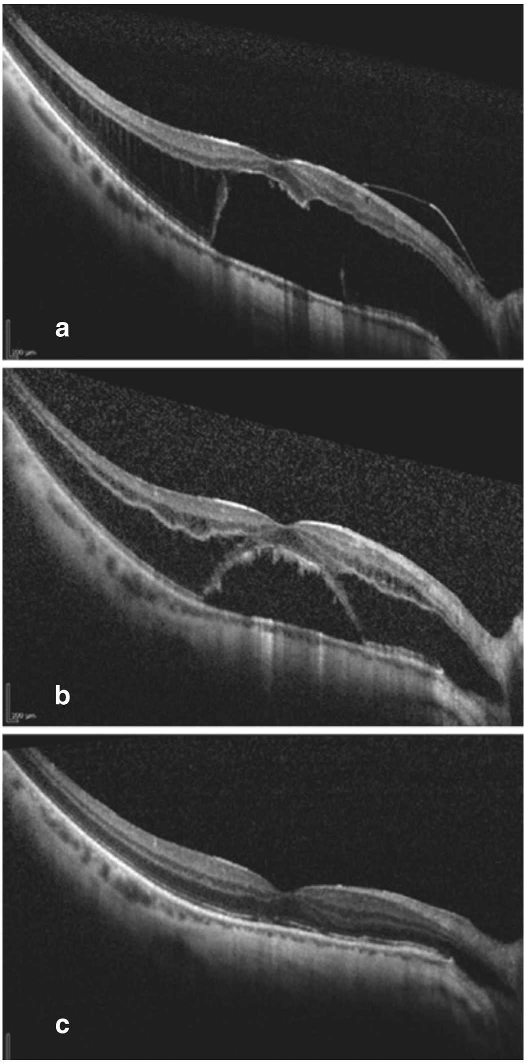


Fig. 26.11 Eye affected by maculoshisis and foveal detachment in a 55-year-old male. (**a**) Preoperative OCT showing the schisis and the foveal detachment with an O-LMH. (**b**) OCT scan 8 months after PPV surgery, showing the resolution of the O-LMH and the persistence of the foveal detachment and the schisis. (**c**) OCT scan, 2 weeks after MB. The O-MS and the foveal detachment are solved

complete hole closure. However, years after the first surgery, the authors observed an opening/reopening of FTMH (Figs. 26.12 and 26.13) due to the progression of the tangential traction.

In conclusion, the surgical treatment of MTM should be customized per patient depending on the stage of the disease.

26.5.3 Role of ILM Peeling

In literature, there is no agreement on the role of ILM peeling. On one hand, it was shown that ILM peeling with ILM flap increased the chance of anatomical success of MHMD [48, 50]. However, it was also well shown that ILM peeling increased the risk of iatrogenic FTMH [52] when cases of MD without FTMH were treated. Therefore, the removal of the inelastic ILM should be postponed to obtaining an attached macula by implanting an MB, in order to reduce this risk. Once the macula is flat, surgeons may perform PPV with or without ILM flap to release the tangential traction exerted by the ILM and to treat the FTMH, when present.

26.6 The Macular Buckle

26.6.1 Preoperative Assessment of the Eye and Patient

A complete slit lamp examination is mandatory. BCVA and microperimetry are useful methods to follow the postoperative functional change. Refraction should be checked in the treatment eye and in the fellow eye. An average 2.0 diopters hyperopic shift should be expected when implanting properly the MB. If the eye is still phakic, it is preferable to implant the buckle first and then proceed with the lens removal if needed. In cases of severe cataract compromising the intraoperative view, a choice can be made either to leave the eye aphakic and proceed with a second implant later, or preferably, to implant an IOL with a myopic residual target refraction. Any previous surgery linked to a change in refraction in the treated or fellow eye should be known, in order to plan the final refractive target. Axial length should be measured preoperatively and periodically after MB.

Any previous surgery should be known. A previous episcleral surgery or episcleral devices such as glaucoma valves could interfere with the implantation of the buckle.

Motility of the eye and diplopia should be assessed before surgery, in order to better judge if

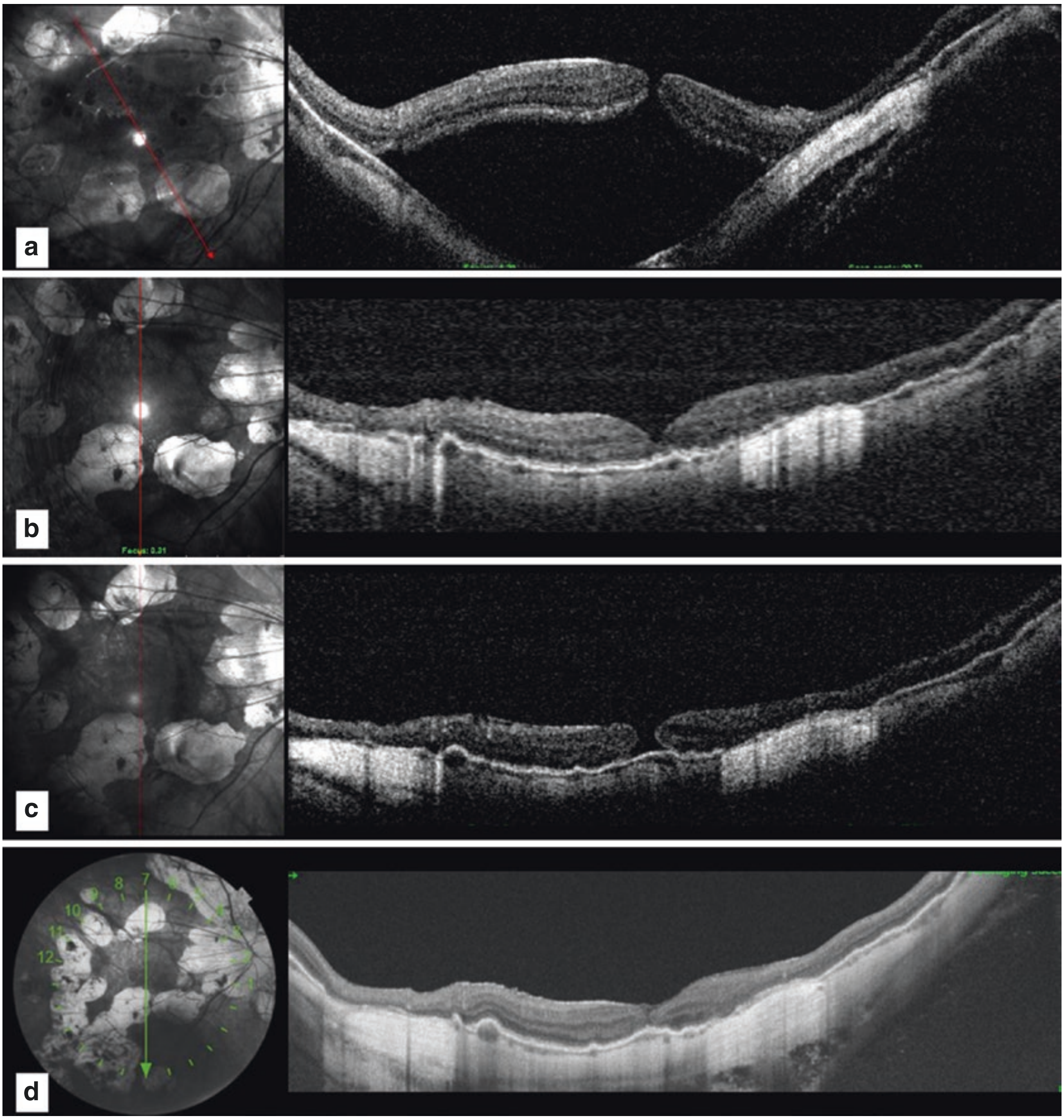


Fig. 26.12 Eye affected by macular detachment with full-thickness macular hole, in a 51–year-old female. (**a**) Preoperative OCT showing the macular detachment with an FTMH. (**b**) OCT scan 1 year after MB, showing the resolution of the detachment. The FTMH appears closed. The indentation is flat. (**c**) OCT scan, 3 years after MB. The eye developed a reopening of the FTMH due to residual tangential traction. (**d**) OCT 1 month after PPV and ILM peeling to solve the FTMH

possible postoperative limitation in the eye movement were induced by the buckle or were present preoperatively and in order to adequately manage them.

Preoperative MRI is not necessary. Collecting data on the original shape of the entire eye and the staphyloma could be helpful in a clinical study setting and postoperatively in order to verify the position of the buckle in relation to the optic nerve (Fig. 26.14).

The category of Myopic Maculopathy according to the International Photographic Classification and grading system [53] should be noted, to better understand the potential postoperative gain in visual function, based on the amount and location of atrophic areas. Suspect signs of

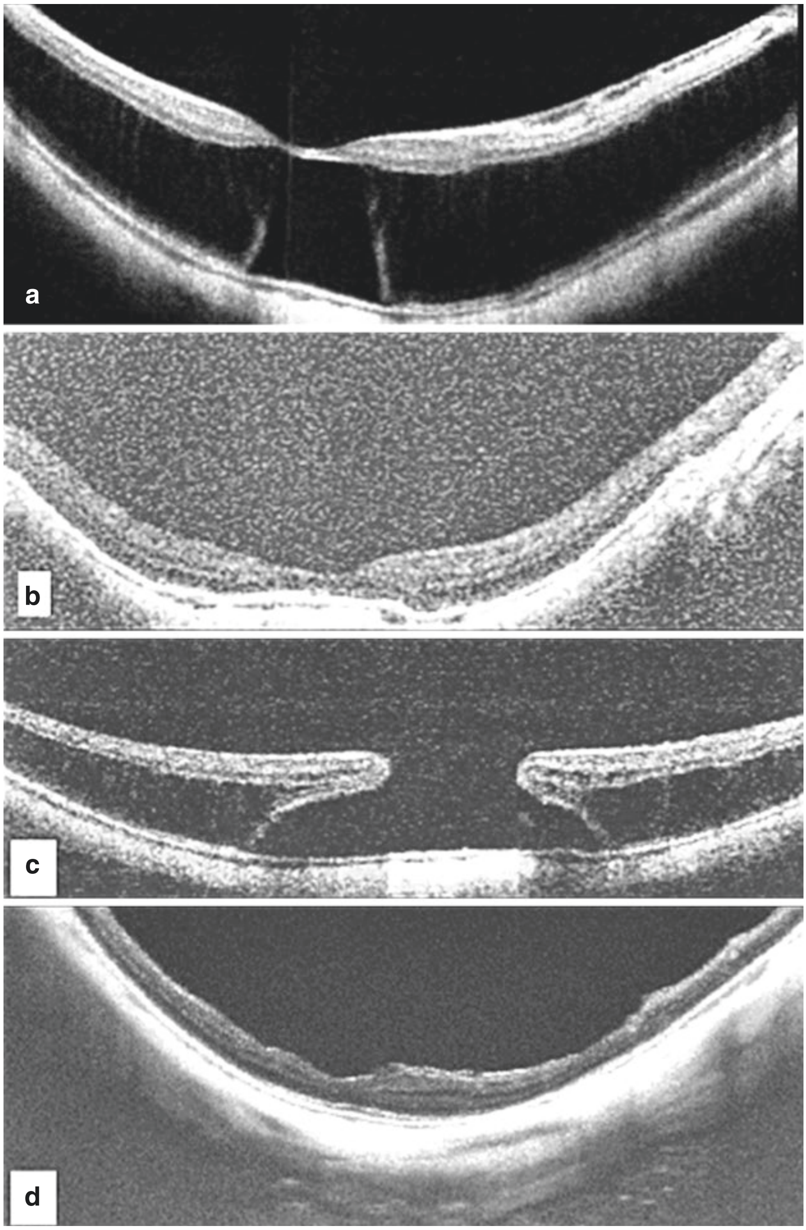


Fig. 26.13 Eye affected by maculoschisis with foveal detachment and outer lamellar macular hole, in a 39-year-old female. (**a**) Preoperative OCT showing the schisis and the foveal detachment with an O-LMH. (**b**) OCT scan 1 year after MB, showing the resolution of the O-LMH, of the foveal detachment and of the schisis. The indentation is flat. (**c**) OCT scan, 3 years after MB. The eye developed an FTMH due to residual tangential traction. (**d**) OCT 1 month after PPV and ILM peeling to solve the FTMH

CNV should be noted in order to promptly allow proper treatment. Wide field fundus photo offers an easier and more accurate classification of the staphyloma [54] (Fig. 26.9).

OCT is the gold standard examination and the main guide to MTM management. Vertical and horizontal OCT scans (at least 9 mm wide) and 3D reconstruction, when available, are useful in understanding the change in the shape of the posterior pole, not only from the preop to the postoperative time, but also during the follow-up.

26.6.2 Indication to the Treatment with Macular Buckle

Macular buckle is indicated to treat prevalent tractions that are perpendicular to the retinal

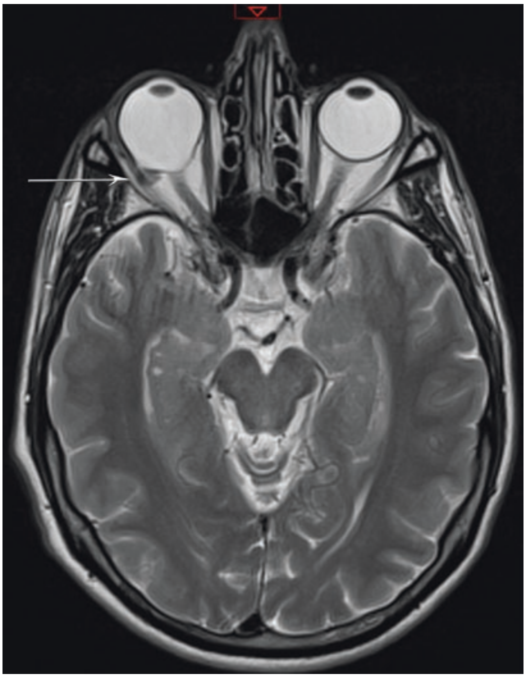


Fig. 26.14 MRI of a patient operated with macular buckle. The right eye is highly myopic and the section of the buckle is indicated by the white arrow

plane. Considering the pros and cons of the actual surgical technique, we advise applying *macular buckle alone* in cases of:

1. Outer maculoschisis with I-LMH
2. Maculoschisis associated with macular detachment
3. Complete macular detachment

Our advice is to apply *macular buckle in combination to PPV*, in the following cases:

1. FTMH associated with outer maculoschisis
2. FTMH associated with maculoschisis and macular detachment
3. Complete macular detachment with FTMH

Our advice is to apply *PPV a few months after macular buckle*, in case of I-LMH still symptomatic after treating the maculoschisis (or maculoschisis + macular detachment) with a buckle.

26.6.3 Anesthesia

MB surgery can be performed under general anesthesia but also under local anesthesia and sedation. In case of local anesthesia in high myopic eyes, sub-Tenon with blunt cannulas is preferable over peribulbar with needle, to lower the risk of scleral perforation.

Parolini proposed a technique which implies to stabilize the globe by holding the superior and the lateral rectus muscle. Therefore, as in any episcleral surgery when traction is applied to the muscle, attention needs to be paid intraoperatively to an acute drop in heart rate.

26.6.4 Postoperative Care

Postoperative care resembles the one of any episcleral surgery. The eye is red and swollen for at least 1 week. Steroid and antibiotic drops should be advised for the first 2 weeks. The follow-up should be scheduled at least at 1 day, 1 week, 1 month, 3–6–12–18–24 months, and then every year.

26.6.5 Complications of the Macular Buckle and Their Management

Some degree of diplopia (particularly in the temporal gaze on the side of the MB location) may occur in 6% of patients in the first postoperative weeks. It is advisable to counsel the patient to move the eye in different directions for 10 min, 3–4 times every day for the first month, in order to lower the chance of formation of fibrotic membranes around the buckle and around the muscles, Tenon's and conjunctival complex. This advice will lower the chance of postoperative diplopia.

Pain is limited and easily treatable in the first week with proper therapy.

Diplopia and pain were mostly linked to the excessive size of the first models of MB.

Exposure of the lateral arm of the buckle through the conjunctiva might occur months or years after surgery. Minimal exposure can be treated by covering the lateral arm with pericardium or donor sclera. In case of recurrent exposure, the buckle can be removed safely.

26.6.6 Effect of Macular Buckle over Time and Effect of Buckle Removal

If the buckle is removed within 3 months after surgery, the MTM could relapse with sudden vision loss (Fig. 26.15). When the buckle is removed

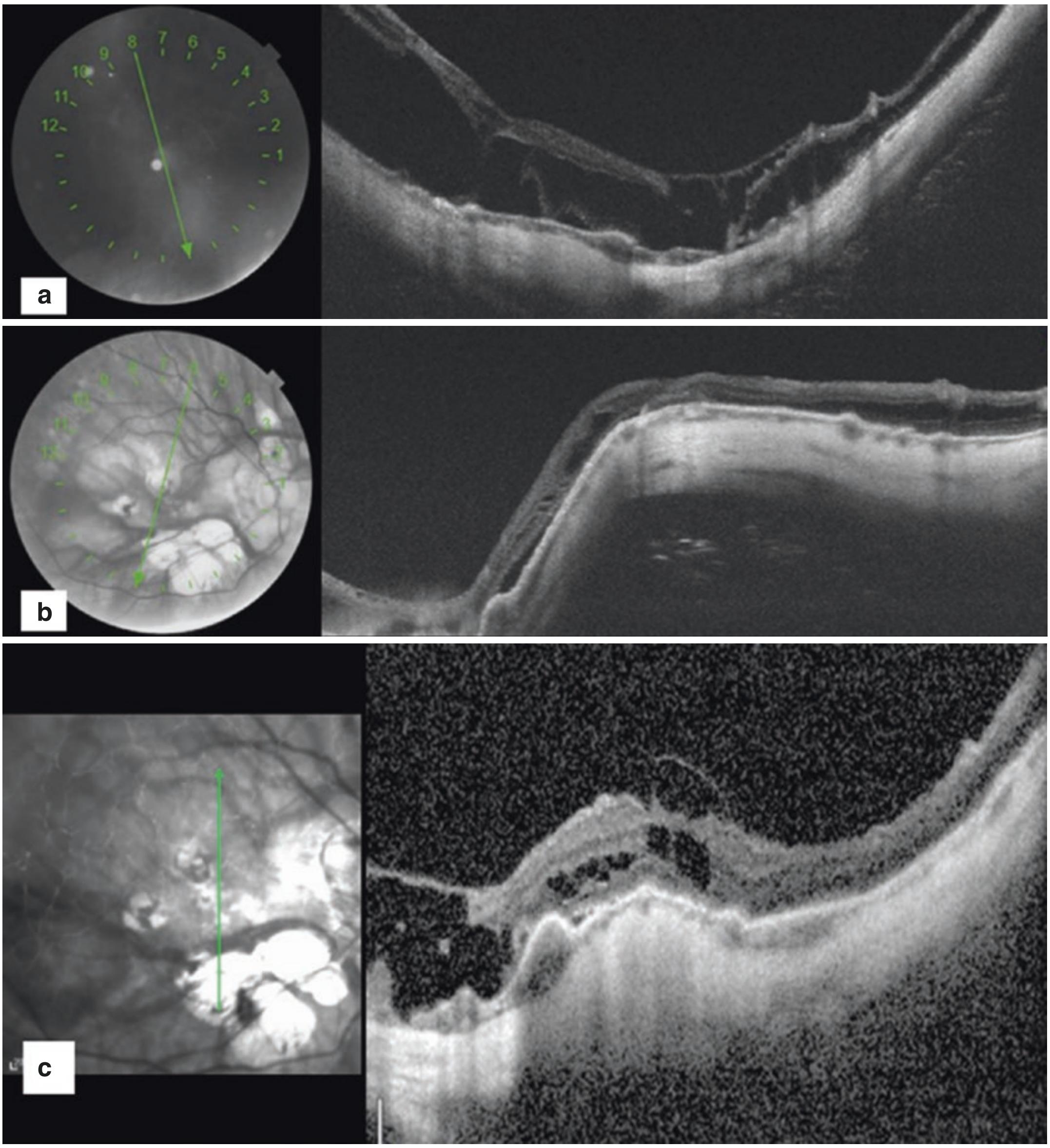


Fig. 26.15 Eye affected by maculoschisis and areas of detachment. (**a**) Preoperative OCT showing a schisis with areas of MD and an O-LMH. (**b**) Postoperative OCT after combined MB + PPV surgery without ILM peeling showing a successful resolution of the schisis and the O-LMH. The shape is now convex over the buckle. (**c**) Recurrence of MTM, immediately after MB removal, due to pain. The MB had been implanted only 2 months before removal

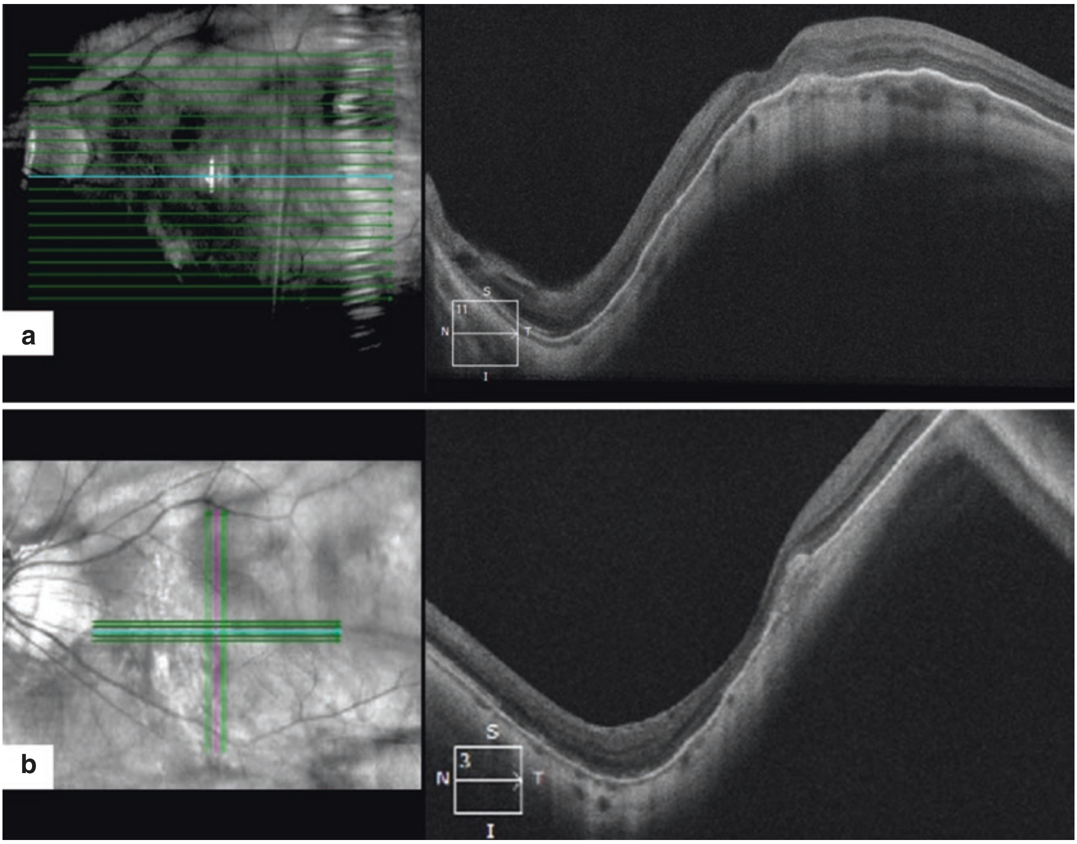


Fig. 26.16 (**a**) Postoperative OCT showing the convex shape of the posterior pole, 4 years after MB implantation. (**b**) OCT scan 2 months after MB removal. The shape of the posterior pole is convex and the fovea and choroid appear thinner. The juxtafoveal CNV occurred 1 year after MB implantation

years after surgery, the anatomical benefit remains although the indentation becomes less pronounced (Fig. 26.16). We advise not to remove the buckle whenever possible or to for at least 6 months.

The buckling effect is always more evident in the first month, then a mild release of indentation is visible (Fig. 26.19). However, the new scleral shape, obtained 2 months after surgery, seems to remain unchanged in most of the cases when the buckle is not removed.

The ideal final shape of the sclera and retina complex is horizontal (Fig. 26.17).

26.6.7 Evolution of the Surgical Technique

Different models of macular buckle have been proposed in the years. The first technique consisted of suturing a sponge to the sclera behind the macula. This technique has been abandoned because too difficult and links to a high rate of complications.

Different models have been proposed to overcome this difficulty such as the model of Devine, Ando, and Landolfo [55].

The idea was to be able to move the sutures anteriorly in a safer and more accessible location.

The first model of MB proposed by Parolini was created by inserting a stainless steel wire into a silicone sponge, 7 mm wide and 5 mm thick (507 Labtician). The sponge could be bent to an L-shape, with a short side, called head, to buckle the macula, and a long side, called arm, to allow an anterior suture. The MB was inserted by pushing the head behind the macular sclera, through the superotemporal quadrant, leaving

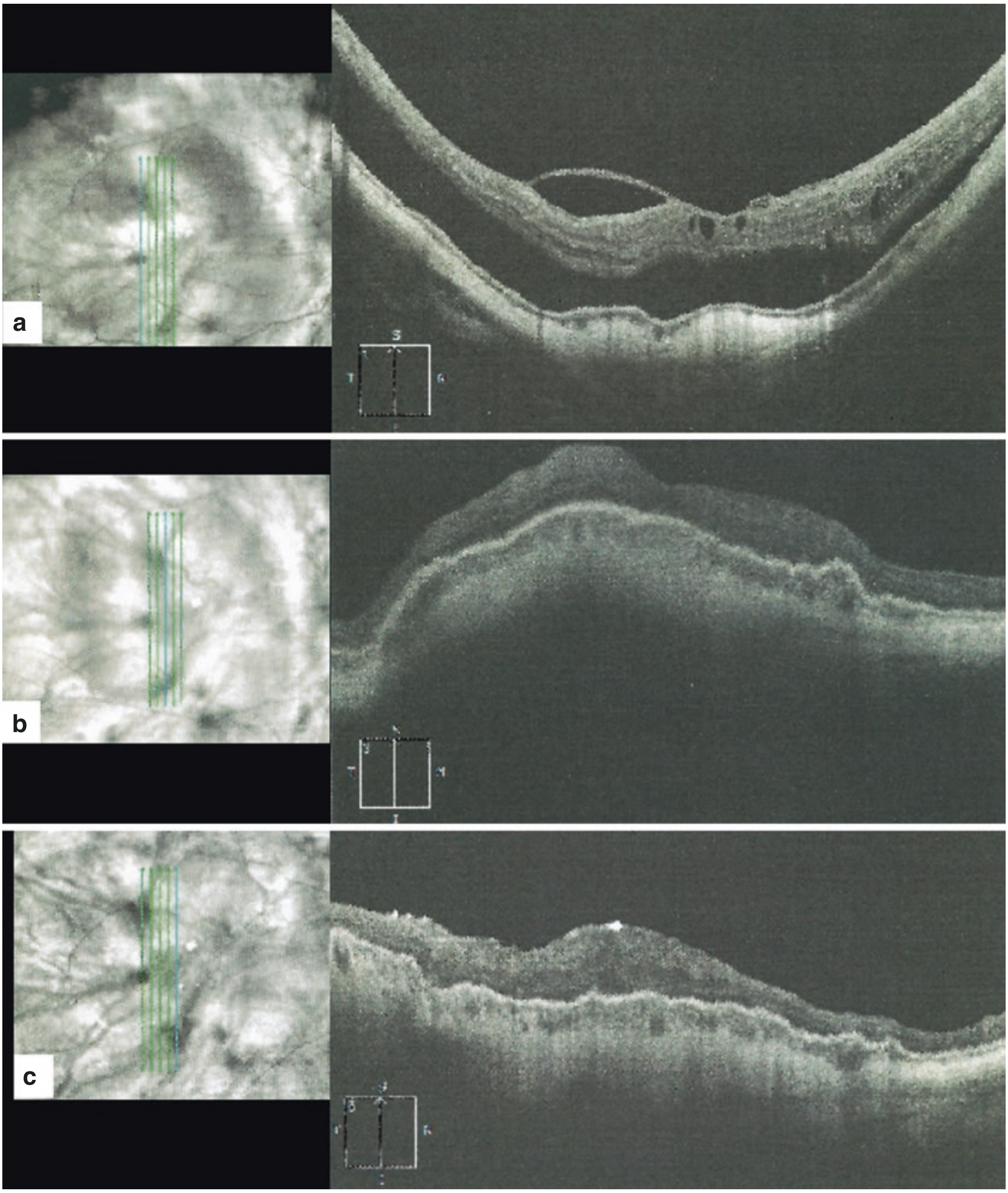


Fig. 26.17 (**a**) Preoperative OCT showing the concave shape of the posterior pole, in an eye with macular detachment in a posterior staphyloma. (**b**) OCT scan 1.5 months after MB implantation. The shape of the posterior pole is convex and the fovea and choroid appear thicker. (**c**) Vertical OCT scan 6 months after MB implantation. The shape of the posterior pole is horizontal

the arm parallel to lateral without the need of detaching any muscles. The sutures needed to stabilize the arm were placed anteriorly at the level of the insertion of the lateral rectus muscle. The first results were presented at the EVRS meeting in 2009 and at the Heatam meeting in 2009. Later, in 2011, the model was modified (Figs. 26.18 and 26.19) by substituting the stainless steel stent with a titanium stent covered by a silicone sleeve (70 Labtician), in order to avoid

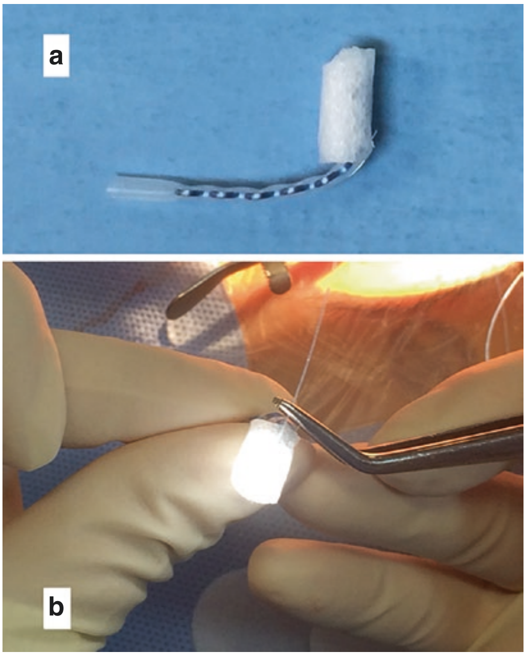


Fig. 26.18 Example of macular buckles used by the author. (**a**) A titanium stent was covered by a silicone sleeve in the arm of the MB, while the head was covered by a silicone sponge. (**b**) MB with a fiber optic light inside the head, to control the final position of the buckle using scleral transillumination

the extrusion induced by the sponge. The solid silicone covering the head of the buckle was replaced with a soft sponge, with the aim to avoid atrophy of the RPE induced by acute angles of solid silicone. Moreover, to assess the final position of the MB, the use of a panoramic microscope and two optic fibers positioned into the pars plana and into the head of the buckle was adopted (Figs. 26.18 and 26.19). The scleral transillumination helps the surgeon to manage the exact position of the buckle and center it underneath the fovea and in particular underneath the macular hole, if present. The size of the head of the buckle should be 7 mm by 8–10 mm to avoid the risk of inducing pain, diplopia, or limitations to eye movement.

The MB is positioned in the superotemporal quadrant with the lateral arm parallel either to the lateral or to the superior rectus muscle. The first option leads to buckle the macula from the temporal side to the nasal side. The second option leads to buckle the macula from 12 o'clock to 6 o'clock and parallel to the optic nerve. This position reduces the risk of optic nerve touch, extrusion, and diplopia.

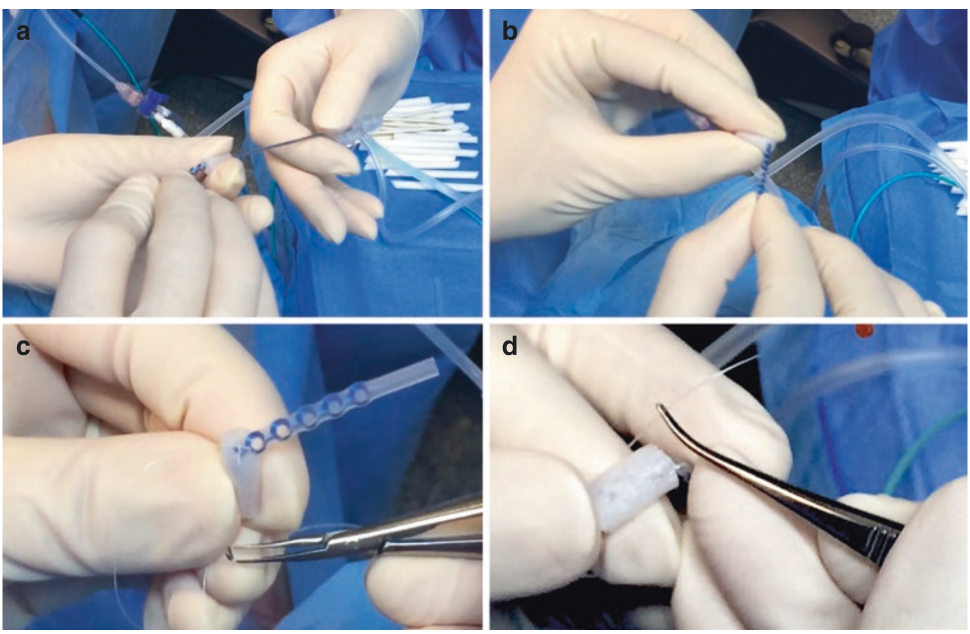


Fig. 26.19 Key steps to assemble a macular buckle. (**a**) Insertion of the titanium stent inside a soft silicone sponge. (**b**) Bending of the arm of the MB. (**c**) Fixing the silicone sponge to the arm. (**d**) Insertion of a fiber optic light inside the head of the MB

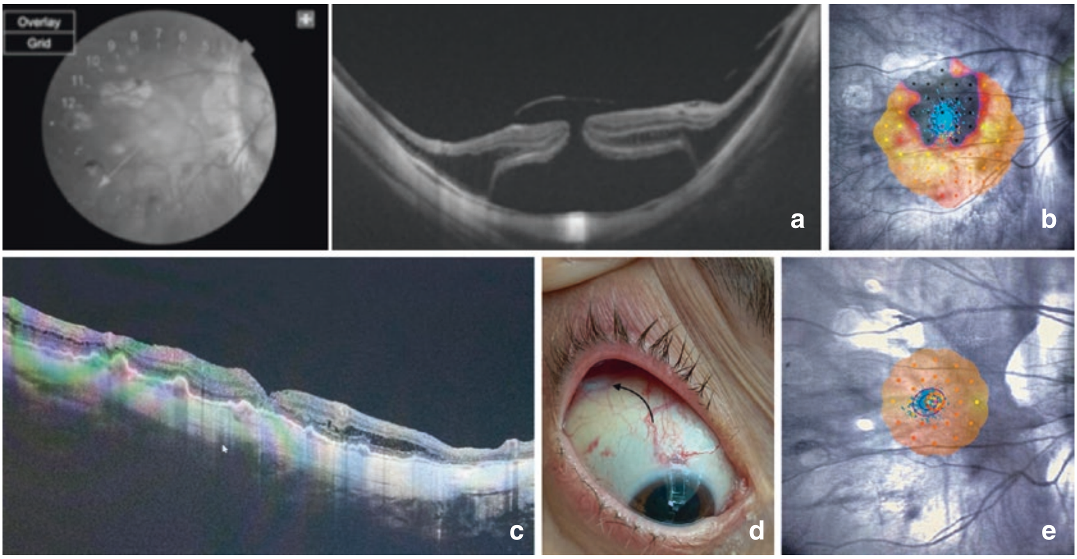


Fig. 26.20 Case report of 56-year-old female affected by MTM. (**a**) SD-OCT showing an MD with an FTMH. (**b**) Preoperative microperimetry. (**c**) Postoperative OCT 1 month after combined MB + PPV surgery with ILM inverted flap technique. (**d**) Postoperative picture of the anterior segment. The arrow shows the arm of the MB barely visible beneath the conjunctiva. (**e**) Postoperative microperimetry

The final shape of the posterior sclera should be as horizontal as possible, resembling the normal posterior pole. An excessive change in the shape of the macula, with a final convex profile, could induce metamorphopsia, unwanted tangential, or excessive refractive modifications. Therefore, the most suitable shape for the head of the buckle is a flat one, in order to reach a flat scleral surface.

26.7 Case Report

Here we report a case of a 56-year-old female affected by MTM in her right eye (Fig. 26.20a, b). This patient was followed up for 3 years before surgery, showing a progressive worsening of both BCVA and her clinical picture. At last follow-up, SD-OCT showed an FTMH with an MD. The patient was directed to a combined surgery.

An MB and a PPV with ILM inverted flap technique were performed. Figure 26.20-C shows the postoperative results 1 month after surgery. A complete macular flattening was obtained, with a complete closure of an FTMH. Figure 26.20-D shows the anterior segment of our patient, with the arm of the MB visible beneath the conjunctiva.

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No financial disclosure.

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