Review article

Current concepts and cutting-edge techniques in myopic macular surgeries

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ABSTRACT

Myopic foveoschisis and macular hole with a retinal detachment are two major diseases associated with posterior staphyloma that are specific to high myopia. The pathogenesis is a combination of various types of traction from the vitreous cortex, epiretinal membrane (ERM), internal limiting membrane (ILM), and microvessels. Foveoschisis typically starts with retinoschisis, and a retinal detachment subsequently develops as a result of traction on the inner retina. The stress on the fovea eventually opens a small hole and leads to retinal detachment from a macular hole; thus, both are closely related. These two pathologies can be treated with vitrectomy. A foveal detachment is the best indication for surgery because of the greatest visual improvement. The routine surgical procedures are vitreous cortex removal with triamcinolone acetonide, ERM peeling, ILM peeling stained with Brilliant Blue G, and gas tamponade. The necessity for ILM peeling and gas tamponade for myopic foveoschisis remains controversial. A postoperative macular hole is a severe complication in foveoschisis, and a photoreceptor inner/outer segment defect seen on optical coherence tomography images obtained preoperatively is a risk factor for macular hole. A foveal nonpeeling can be considered to avoid foveal trauma. The inverted ILM peeling technique is a new option to enhance macular hole closure. Both techniques seem to enhance retinal restoration; however, the visual benefit has not been confirmed. A long-shaft forceps facilitates precise maneuvers. Vitrectomy for highly myopic macular diseases remains challenging; however, an understanding of the pathogeneses and innovations in vitreous surgical instruments and techniques will facilitate safer surgeries.

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1. Introduction

Myopic foveoschisis is very common in patients with high myopia and occurs predominantly in middle-aged to older women. Myopic foveoschisis develops prior to a macular hole with retinal detachment, and both are major macular diseases that require vitrectomy. However, the surgery itself remains challenging due to atrophic and thin retinas, multiple and fragile membranes adhering to the retina, and the location of the retinal fundus far from the entry site. This article discusses the background information including clinical manifestations and pathogenesis, and the cutting-edge techniques in surgical procedures.

2. Pathogenesis

Myopic foveoschisis is characterized by retinoschisis and subsequent retinal detachment specific to highly myopic eyes. Posterior staphyloma is a risk and has a higher prevalence than in eyes without staphyloma.1 Myopic foveoschisis was first described in the 1950s,2 and was reported to commonly occur in 10 of 32 highly myopic eyes.3 However, it is difficult to diagnose myopic foveoschisis correctly without optical coherence tomography (OCT), which enables visualization of the microarchitecture and provides information to facilitate an understanding of the pathophysiology in high-myopic cases. Myopic foveoschisis is substantially a tractional disease that is generated from various components. The vitreous cortex is one cause of the inward traction on the retina. Vitreous adhesion to the retina and vitreoschisis is seen frequently during vitrectomy. Epiretinal membranes (ERMs) are common and also generate traction. The rigidity of internal limiting membranes (ILMs) and the retinal vascular traction are unique and both are newly found.
pathogenesis. Detachment of the ILM from the other retinal layer is often observed on OCT images\(^4\) (Fig. 1). This indicates that the ILM is less flexible than the other retinal layers and exerts inward traction on those layers. Retinal vascular traction is postulated based on a unique OCT finding, the so-called retinal microfolds.\(^5,6\)

Retinal microfolds appear on OCT images as small peaks in the inner retina and are a typical finding after vitrectomy performed to treat myopic foveoschisis (Fig. 2). The retinal vessels, especially the retinal arterioles, are less flexible and cannot be stretched as much as the other retinal components. Thus, myopic foveoschisis is caused by multiple factors and can be regarded as a split between the flexible outer retina and the inflexible inner retina.

Macular holes often lead to retinal detachments in highly myopic eyes. Histologic studies of specimens obtained during vitrectomy have shown that the retinal detachment results from the tangential traction of the vitreous cortex and/or thin ERMs adhering to the retinal surface.\(^7,8\) OCT has demonstrated a more detailed mechanism related to myopic foveoschisis. Myopic foveoschisis starts with retinoschisis but ultimately leads to a macular hole through a focal retinal detachment.\(^9\) Two types of macular holes develop in high myopia, one of which is flat without retinoschisis and the other is the retinoschisis type.\(^10\) The latter exerts powerful traction and is highly likely to progress to a retinal detachment. It is often rapidly progressive and can progress in only 1–2 weeks to widespread detachment from formation of a hole. The flat type does not exert traction, is typically stable, and has a higher anatomic postoperative success rate compared with the retinoschisis type.

3. Clinical manifestations and diagnosis

OCT shows a variety of appearances of myopic foveoschisis including lamellar holes and retinal cysts.\(^11\) Myopic foveoschisis begins as retinoschisis without a retinal detachment (i.e., the retinoschisis type). A retinal detachment can start at the fovea after several months or years if there is sufficient traction (i.e., the foveal detachment type; Fig. 3).\(^9\)

The natural course of myopic foveoschisis is poor,\(^12,13\) and 11–50% of patients have a retinal detachment and/or macular hole formation within 2–3 years of follow-up without treatment. The high risk of severe visual loss from macular holes with retinal detachments is a motivation for surgery.

A macular hole with a retinal detachment has a wide range in the area. Some patients are stable and the pathology is localized within the posterior staphyloma for months; however, most proceed to the development of an extensive detachment beyond the edge of the staphyloma. A small hole is seen in the central macular area on ophthalmoscopy and can be confirmed by the OCT, which generally shows a detached retina and a hole with or without surrounding retinoschisis.

4. Treatment

4.1. Surgical goals and indications

Vitrectomy is the most common treatment for myopic foveoschisis.\(^14–18\) The surgical goal is to release all retinal traction to reattach and reconstruct the normal structure. As mentioned previously, there are several subtypes; however, the subtypes with the
best surgical indications remain controversial. We investigated the surgical results and found that eyes with a foveal detachment are good surgical candidates for visual improvement. Other investigators have also reported that a foveal detachment is a positive predictive factor for favorable visual outcomes. However, there is no consensus about the surgical indication, and any type of pathology can be an indication for surgery.

4.2. Vitreous cortex and ERM peeling

Vitreous surgery includes vitreous cortex separation from the retina, dye-assisted ERM/ILM peeling, and gas tamponade normally with air or sulfur hexafluoride. Because multiple layers of membranes of different origins are attached to the retina, maximal care must be taken to confirm that all components are removed. After core vitrectomy, triamcinolone acetonide is applied to visualize the thin vitreous membrane and separate it from the retina with intravitreal forceps or Tano diamond-dusted membrane scraper (Fig. 4). Once the posterior vitreous detachment is complete, the presence of an ERM, which is often thin and barely visible, must be confirmed. In such cases, the use of trypan blue dye can be considered. An ILM of 2–3-disk diameter is peeled off after dyeing the tissue with Brilliant Blue G.

4.3. ILM peeling

ILM peeling remains controversial in myopic foveoschisis; however, we prefer this procedure for the following reasons. First, an ILM detachment indicates that the inward traction is seen predominantly in highly myopic eyes. Second, occult fibrin/membrane formation is often seen on the ILM surface in electron microscopic studies. Finally, reoperation with ILM peeling is often effective for persistent and recurrent myopic foveoschisis.
Macular hole formation is one of the most severe postoperative complications, with an incidence rate of approximately 20%. To identify the risk factors for secondary full-thickness macular holes after pars plana vitrectomy with ILM peeling, we retrospectively reviewed patients who had undergone those procedures to treat myopic foveoschisis. A macular hole developed postoperatively in eight (19.0%) of 42 eyes. No significant association between age, axial length, visual acuity (VA), foveal status, posterior staphyloma, or choriotreatical atrophy was found in patients with and without macular holes. Only the percentage of eyes with an inner/outer segment junction defect was significantly higher.

The pathogenesis of secondary macular holes after vitrectomy for macular foveoschisis remains unclear; however, this may suggest the critical role of ILM peeling. Gass hypothesized that the Müller cell cone supplies structural support to the fovea and plays a critical role in the pathogenesis of macular holes. Potential trauma to the underlying Müller cells caused by ILM peeling may be a possible explanation for postoperative macular hole. ILM peeling may result in loss of Müller cell end feet in the area from which the ILM was peeled and weakening of the macular glial structure.

4.4. Modified techniques in ILM peeling

A foveal nonpeeling technique is a way to avoid trauma (Fig. 5). However, this method is controversial. Other investigators reported the largest published series in which they compared conventional ILM peeling and this new technique. They found less likelihood of macular hole formation using this technique. However, interestingly, the visual results did not significantly improve. This technique has a significant impact on anatomic success but may not affect the visual success. This is a limitation of this technique that must be considered.

The rate of macular hole closure is even less in highly myopic eyes compared with nonmyopic eyes, which is reported in approximately 25–40% of cases. The risk that a hole might not close is higher in cases with preoperative retinoschisis or retinal detachment, which is likely because of the lack of retinal redundancy due to the deep staphyloma. The inverted ILM peeling technique enhances the macular hole closure rate in highly myopic eyes (Fig. 6). However, the effect on visual results is controversial.

We developed and tested long-shaft forceps (+5 mm longer) in highly myopic eyes (Fig. 7) of 14 patients during ILM peeling by scoring the impression of four different locations (proximal, distal, superior, and inferior to the macula) in the posterior pole. The forceps was useful in eyes with axial lengths ranging from 27.89 mm to 29.9 mm. This forceps is currently available from the Dutch Ophthalmic Research Center (Zuidland, The Netherlands).

4.5. Air/gas tamponade

The fluid is exchanged with gas and replaced with half air at the end of surgery. The patient must remain in the face-down position for 1 day if there is no macular hole. The effectiveness of gas tamponade is controversial; however, Kim et al. reported that this procedure significantly shortened the time to retinal reattachment, although there was no difference in the postoperative visual outcomes. A long period of gas tamponade was associated with better visual outcomes in a small case series. In cases with macular holes, a longer period of gas tamponade with perfluoropropane was used to enhance the reattachment. However, a long period of tamponade may not be necessary after the inverted ILM flap technique described previously. Further investigation is needed to confirm this.

4.6. Surgical outcomes

The prognosis of myopic foveoschisis is favorable after vitrectomy. In most cases, the retina is reattached at least around the fovea. Retinal reattachment sometimes is slow and can take from 6 months to 1 year. Residual retinoschisis, retinal detachment, or both are observed at the edge of the posterior staphyloma; however, when this pathology is far from the macula, the recovery of the visual function is not compromised. We reported that approximately 50% of patients with the retinoschisis type of macular hole had visual improvement 6 months postoperatively, as did 80% with the foveal detachment type, and 30% with the macular hole type.

Another group of investigators reported similar results, that is, the final vision in the foveal detachment group and nonfoveal detachment group improved in 70% and 42%, was unchanged in 26% and 33%, and worsened in 4% and 25% of the eyes, respectively. The prognosis is much poorer in cases with macular holes, therefore, surgery must be performed before a macular hole develops.

The prognosis of macular holes with a retinal detachment is relatively poor. The postoperative VA is an average of 20/200 or less, and retinal reattachment occurs in approximately 70% of cases after the initial surgery. In addition, the macular holes do not close in most cases. Macular buckling, which can be considered when the retina is resistant, converts the vector force on the retinal surface and pushes the retina onto the retinal pigment epithelium. This is why this procedure normally has a higher success rate of over 90% compared with vitrectomy.

5. Concluding remarks

Myopic macular diseases result from traction of multiple components, and the surgical goal is to release all traction on the retina. Vitrectomy instruments continue to evolve, and new techniques are being introduced to achieve better anatomic success. However, the surgery remains challenging. The unique pathophysiology in this special environment must be understood, and efforts must be made to improve vitreous surgery.

References
