



# Vitreotomy with peripapillary internal limiting membrane peeling for macular retinoschisis associated with normal-tension glaucoma

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## ABSTRACT

**Purpose:** Although vitrectomy has been reported to be effective for the treatment of macular retinoschisis associated with glaucoma in a few case series, the surgical techniques have yet to be established. This article aimed to describe the cases of two patients with macular retinoschisis who underwent vitrectomy with peripapillary internal limiting membrane peeling around the defective area of the retinal nerve fiber layer.

**Observations:** Both patients had been diagnosed with normal tension glaucoma and treated with eye drops to stabilize intraocular pressure. Progression of macular retinoschisis and accompanied vision loss were observed in both cases. Twelve months after the surgery, both patients had resolution of the retinoschisis and improvement in best corrected visual acuity.

**Conclusions and importance:** Our surgical technique may be effective for the resolution of macular retinoschisis in eyes with normal tension glaucoma.

## 1. Introduction

Retinoschisis involving peripapillary and macular regions can occur as a result of optic nerve head (ONH) structural abnormalities, such as ONH pits, optic nerve colobomas, X-linked macular schisis, and high myopia.<sup>1–6</sup> In addition, recent reports using optical coherence tomography (OCT) demonstrated that peripapillary retinoschisis occurs in approximately 3.1%–6.0% of eyes with glaucomatous ONH changes that do not have any other structural abnormalities.<sup>7–9</sup> In contrast, macular retinoschisis that expands from peripapillary retinoschisis is a relatively uncommon condition that can cause visual impairment.

Although a few case reports have suggested that peripapillary and macular retinoschisis can resolve by intraocular pressure (IOP) stabilization, or even without treatment in eyes with glaucoma,<sup>10–12</sup> Inoue et al. reported that macular retinoschisis in cases of normal-tension glaucoma (NTG) was not reduced with further reduction of IOP.<sup>13</sup> Two case series showed that vitrectomy could resolve macular retinoschisis and improve visual acuity in eyes with glaucomatous ONH; however, the surgical techniques were not standardized. For example, the surgical techniques included a combination with or without gas tamponade and/or internal limiting membrane (ILM) peeling. Moreover, macular hole development was one of the surgical complications that was found in four eyes (36%) and two eyes (40%) intra- and post-

operatively, respectively. Thus, vitrectomy procedures have yet to be established for the treatment of macular retinoschisis in eyes with glaucoma.<sup>10,13</sup>

Currently, the precise mechanism of peripapillary retinoschisis is not yet fully understood. Recent OCT analyses revealed an existence of micro holes within the retinal nerve fiber layer (RNFL) in 16% of eyes with glaucoma, and that the lateral mechanical stress force likely allows liquefied vitreous fluid to migrate into the holes, resulting in the progression of peripapillary retinoschisis.<sup>7,14,15</sup>

Here, we describe the cases of two patients who had macular retinoschisis associated with NTG that was managed by vitrectomy combined with peripapillary ILM peeling around the defective RNFL area. The aim was to completely release the local mechanical traction.

## 2. Findings

### 2.1. Case 1

The first patient was a 61-year-old female who had macular retinoschisis, macular detachment, and glaucomatous optic neuropathy in her left eye. She had been diagnosed with NTG in both eyes 15 years earlier at a local clinic, and had been treated since then with trabeculoplasty. She was referred to our hospital for gradually worsening vision loss in

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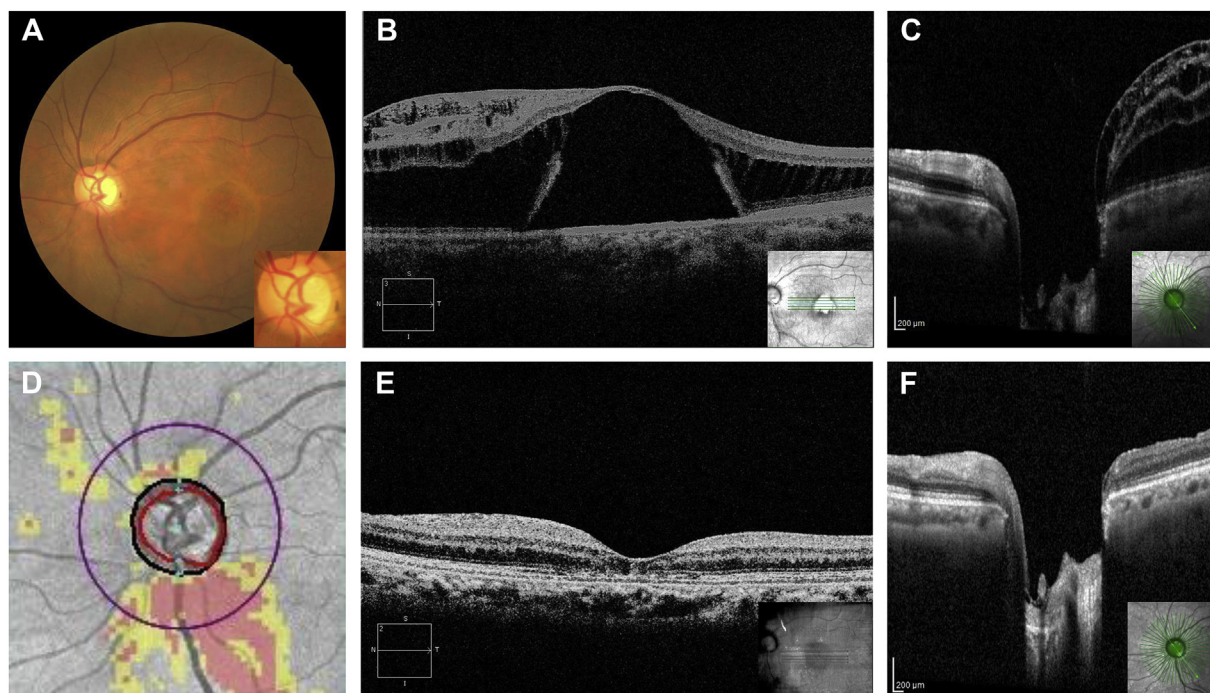
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**Fig. 1.** Funduscopy and optical coherence tomography (OCT) images of Case 1.

Fundus photograph (A) and OCT images (B–F) of the left eye of a 61-year-old woman. A and B: Preoperative fundus photograph and the horizontal OCT scan across the macula showing the outer retinal hole at the fovea and retinoschisis located in the retinal nerve fiber layer, outer plexiform layer, and inner plexiform layer. C: The oblique OCT scan across the optic disc shows that the retinoschisis was connected to the optic disc. D: The preoperative peripapillary RNFL and ganglion cell thickness deviation map showed a thinning of the inferotemporal sector of the optic disc. E and F: Postoperative OCT scans showed resolution of the macular and peripapillary retinoschisis and the outer retinal hole 12 months after surgery.

her left eye. At the first visit, her best-corrected visual acuity (BCVA) was 20/25 and her IOP was 11 mm Hg in the left eye. Funduscopy examination and spectral domain OCT (SD-OCT; Spectralis, Heidelberg Engineering, Heidelberg, Germany; or Cirrus, Carl Zeiss Meditec Inc., Dublin, CA) revealed retinal elevation at the macula, and moderate cupping of the optic disc with a nerve fiber layer defect (NFLD) at the inferotemporal margin. No obvious disc pit in the left eye could be observed in stereoscopic optic disc photographs. Neither an optic pit nor communication between the optic nerve margin and intraretinal and/or subretinal space in the left eye was detected with SD-OCT. Goldmann perimeter showed a superonasal visual field defect consistent with the NFLD. PVD was seen preoperatively in the eye, and she underwent PPV combined with cataract surgery. Residual vitreous cortex was seen intraoperatively around the optic disc, and peripapillary ILM peeling around the NFLD area was performed using the BBG dye (Fig. 4A).

Neither fluid-air exchange nor gas tamponade was performed. Postoperatively, SD-OCT showed a gradually reducing and an almost completely resolved macular retinoschisis (Fig. 3E and F). Her BCVA improved to 20/20 without apparent visual field loss progression (Fig. 2B and C) 12 months after surgery.

## 2.2. Case 2

The second patient was an 84-year-old female who had macular retinoschisis and glaucomatous optic neuropathy in her left eye. She had been diagnosed with NTG of both eyes a year earlier in a local clinic, and had been treated with topical carteolol hydrochloride since

then. She was referred to our hospital for gradually worsening vision loss in her left eye. At the first visit, her BCVA was 20/80 and her IOP was 12 mm Hg in the left eye. Funduscopy examination and SD-OCT revealed macula and moderate cupping of the optic disc with NFLD at the inferotemporal margin. No obvious disc pit in the left eye could be observed in stereoscopic optic disc photographs. Neither an optic pit nor communication between the optic nerve margin and intraretinal and/or subretinal space in the left eye was detected with SD-OCT (Fig. 3A–D). Goldmann perimeter showed a superonasal visual field defect consistent with the NFLD. PVD was seen preoperatively in the eye, and she underwent PPV combined with cataract surgery. Residual vitreous cortex was seen intraoperatively around the optic disc, and peripapillary ILM peeling around the NFLD area was performed using the BBG dye (Fig. 4A).

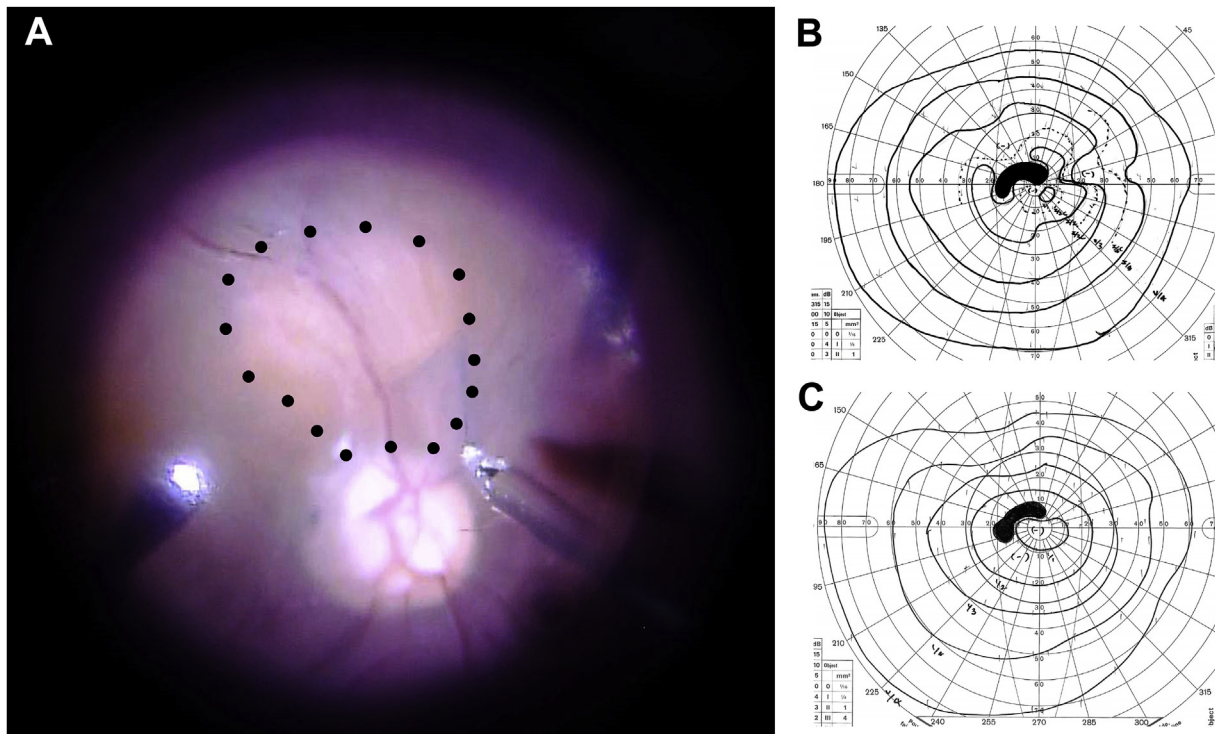
Neither fluid-air exchange nor gas tamponade was performed. Postoperatively, SD-OCT showed a gradually reducing and an almost completely resolved macular retinoschisis (Fig. 3E and F). Her BCVA improved to 20/20 without apparent visual field loss progression (Fig. 4B and C) 12 months after surgery.

## 3. Discussion

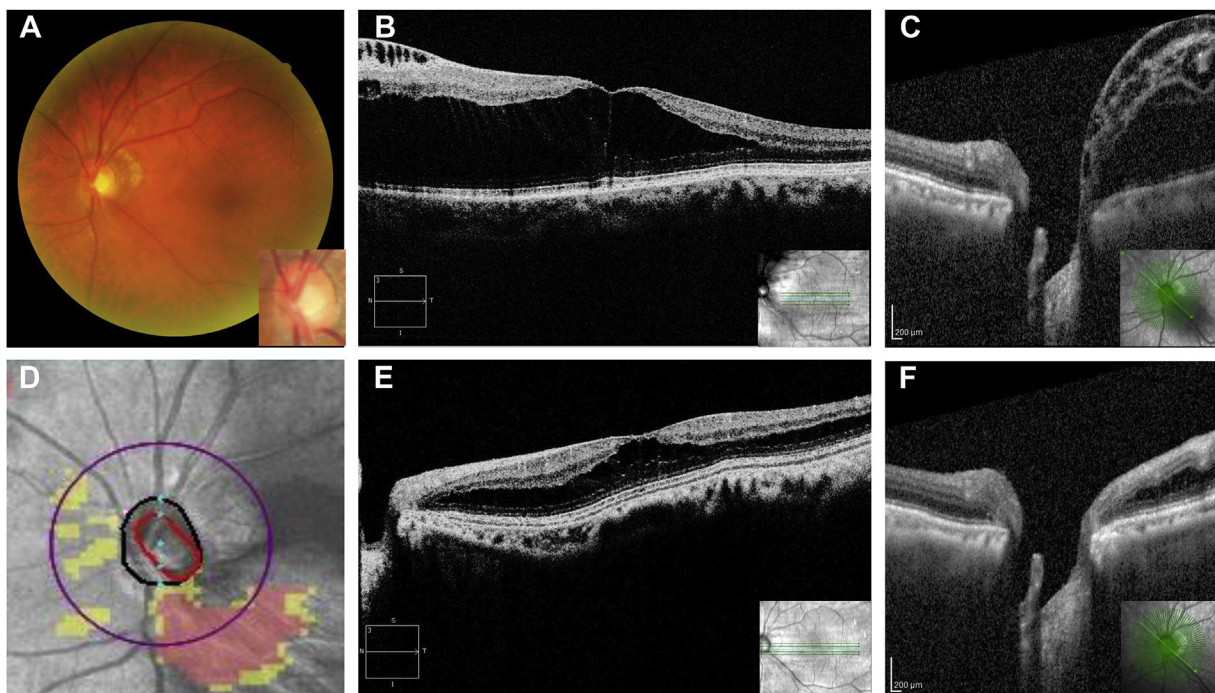
In this article, we reported two cases of surgically successful outcomes after vitrectomy combined with peripapillary ILM peeling around the defective RNFL area for macular retinoschisis in eyes with NTG.

Although retinoschisis has been shown to resolve with the initiation of PVD,<sup>13,16</sup> in our second case, PVD was already present preoperatively (as determined with ophthalmoscopy and SD-OCT), and was confirmed intraoperatively with simultaneous detection of the residual vitreous cortex. The preferable postoperative outcome suggests that the existing vitreous cortex or ILM may contribute to lateral mechanical traction on the defective area of the RNFL in the development of peripapillary

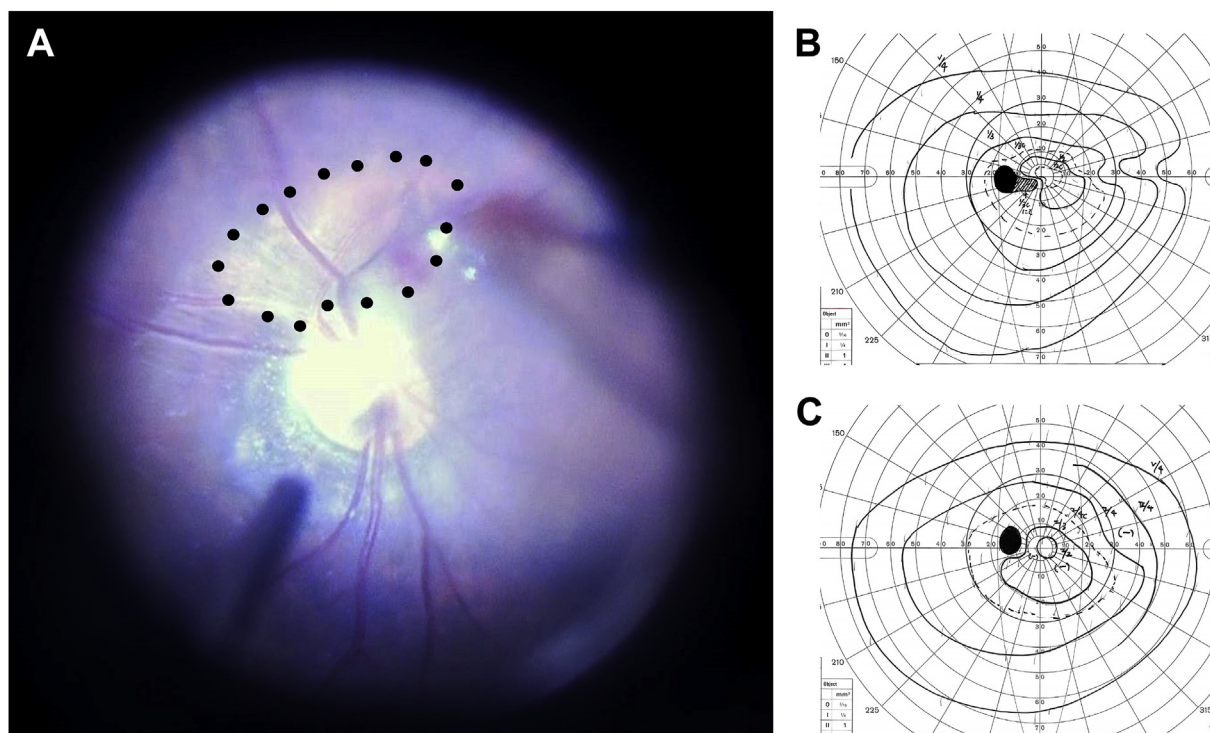




**Fig. 2.** Intraoperative image of the internal limiting membrane (ILM) peeling and visual field testing by the Goldmann perimeter in Case 1. A: An intraoperative image during peripapillary ILM peeling around the defective area of the retinal nerve fiber layer with brilliant blue staining. The area of the ILM peeling at the inferotemporal margin of the optic disc is circled by black dots. B and C: Visual field testing by the Goldmann perimeter preoperatively (B) and 12 months after surgery (C). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)



**Fig. 3.** Fundus and optical coherence tomography (OCT) images of Case 2. Fundus (A) and OCT images (B–F) of the left eye of an 84-year-old woman. A and B: Preoperative fundus image and the horizontal OCT scan across the macula show retinoschisis located in the retinal nerve fiber layer (RNFL), the outer plexiform layer (OPL), and the inner plexiform layer. C: The oblique OCT scan across the optic disc shows that the retinoschisis was connected to the optic disc. D: The preoperative peripapillary RNFL and ganglion cell thickness deviation map show a thinning of the inferotemporal sector of the optic disc. E and F: Postoperative OCT scans show an improvement of the peripapillary and macular retinoschisis with little remaining in the OPL 12 months after surgery.



**Fig. 4.** Intraoperative image of internal limiting membrane (ILM) peeling and visual field testing by the Goldmann perimeter in Case 2.

A: An intraoperative image during peripapillary ILM peeling around the defective area of the retinal nerve fiber layer with brilliant blue staining. The area of ILM peeling at the inferotemporal margin of the optic disc is circled by black dots. B and C: Visual field testing by the Goldmann perimeter preoperatively (B) and 12 months after surgery (C). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

retinoschisis. This mechanistic insight is supported by previous OCT findings regarding the possible existence of micro holes within the defective RNFL area, through which vitreous fluid may migrate accompanied by lateral traction, even in the absence of vitreous traction.<sup>7,14</sup> In our cases, we did not observe micro holes within RNFL defect area in the OCT images.

Meanwhile, in cases without PVD, vitreous adhesion to the surface of the optic disc and/or peripapillary defective RNFL area can be considered the main pathogenesis; thus, PVD creation without ILM peeling may be sufficient for retinoschisis resolution. However, the traction forces exerted by the vitreous cortex or ILM may remain, even after eliminating the effect of the vitreous adhesion. Therefore, with the intention of completely releasing the mechanical traction on the defective RNFL area, we performed peripapillary ILM peeling around the area, even in the case with no PVD.

In the management of optic disk pit maculopathy (OPDM), vitrectomy has been the widely accepted treatment although there is no obvious evidence that vitreous traction plays an important role in the pathogenesis. Recent reports introduced new surgical techniques to improve the surgical outcome.<sup>17</sup> One of these is vitrectomy with packing or covering an inverted ILM flap into or onto the optic pit.<sup>18,19</sup> Since inverted ILM stuffing showed faster resolution of macular schisis than ILM peeling alone,<sup>20</sup> interception of fluid from the vitreous cavity to the subretinal space by closing of the optic pit has been considered important rather than releasing of complete local traction for better surgical outcome in OPDM. Although this surgical technique also includes peripapillary ILM manipulation, as does our approach presented in this study, complete release of mechanical traction on the defective RNFL area is sufficient for resolution of retinoschisis associated with glaucomatous optic neuropathy, which is distinct from the management of OPDM.

The development of macular hole (MH) is a major postoperative complication and is found in approximately 30%–40% of cases following vitrectomy for macular retinoschisis associated with

glaucomatous optic neuropathy.<sup>10,13</sup> Peeling the ILM off of the central fovea could be a risk factor of MH formation, especially in cases with a thin central fovea, which can occur with macular schisis progression. For its prevention, Inoue et al. performed fovea-sparing ILM peeling around the macula in 2 cases, and no MH developed postoperatively. Nevertheless, there is still the concern that ILM peeling around the central fovea can deteriorate visual field sensitivity in glaucomatous eyes.<sup>21</sup> Given that ILM peeling induces Müller cell structure damage, which results in a loss of visual sensitivity, our procedure with minimal ILM peeling can be expected to have a less deleterious effect on the subsequent glaucomatous visual field progression. Although neither of our cases had any apparent visual field loss progression 12 months post-surgery, future research should investigate the effect of this manipulation on the RNFL thickness and defect area, and the following visual field sensitivity changes with a longer observation period and a larger number of cases.

#### 4. Conclusions

We examined two cases with preferable surgical outcomes after vitrectomy combined with peripapillary ILM peeling around the defective RNFL area for the resolution of macular retinoschisis in eyes with NTG. Although we have only presented the results of two cases, our procedure involving minimal ILM peeling may be useful for treating macular retinoschisis in glaucomatous eyes. Further, this procedure may reduce the risk of complications, such as MH development and acceleration of glaucomatous visual sensitivity loss.

#### Patient consent

Consent to publish the two cases was not obtained. This report does not contain any personal information that could lead to the identification of the patients.

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## Authorship

All authors attest that they meet the current ICMJE criteria for Authorship.

## CRediT authorship contribution statement

**Keijiro Ishikawa:** Conceptualization, Methodology, Writing - original draft. **Takuma Fukui:** Investigation. **Shintaro Nakao:** Supervision, Writing - review & editing. **Satomi Shiose:** Investigation. **Koh-Hei Sonoda:** Validation, Writing - review & editing, Funding acquisition.

## Declaration of competing interest

The following authors have no financial disclosures: (KI, TF, SN, SS, KS).

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