Paracentral and Cecocentral Scotomas After Pars Plana Vitrectomy for Rhegmatogenous Retinal Detachment

RAHUL N. KHURANA AND VIVEK R. PATEL

• PURPOSE: To describe novel paracentral and cecocentral visual scotomas after pars plana vitrectomy (PPV) for rhegmatogenous retinal detachment (RRD) repair over a 5-year period.

• DESIGN: Retrospective case series.

• METHODS: This was a retrospective review of all patients who reported visual scotomas after 23- or 25-gauge PPV (Constellation Vision System, Alcon, Fort Worth, Texas, USA) for RRD repair by a single surgeon (RNK) from January 2013 through December 2018. All patients had multimodal imaging (fundus photography, fluorescein angiography, autofluorescence, and spectral-domain optical coherence tomography [OCT] and standardized central Humphrey visual field [HVF] testing) to further characterize the visual scotomas.

• RESULTS: Nine patients reported visual scotomas after PPV for RRD from January 2013 to December 2018 with incidence of 6.4% (9/140). The average age was 61 years (range 53-71 years) and 3 of 9 were female. The preceding RRD was macula-sparing for 6 of 9 patients; all of them involved the right eye. Seven of 9 patients reported the central scotoma within the first week after surgery. All 9 patients noted paracentral or cecocentral location of scotomas involving the inferior temporal visual field. Multimodal imaging was only significant for corresponding focal superior nasal ganglion cell loss on spectral-domain OCT. Two of 9 patients had symptomatic visual loss from the scotoma because it involved the center of fixation.

• CONCLUSIONS: We report a novel central/paracentral visual field defect after PPV for RRD repair. The paracentral scotoma is located inferotemporally and correlates anatomically with ganglion cell loss on spectral-domain OCT. The visual field defect and corresponding anatomic ganglion cell loss suggests a focal retinal injury. We propose that it could be caused by trauma from air flow from the infusion cannula during the air–gas exchange, angled directly toward the superior nasal paracentral retina. Surgeons should be aware of this complication and take precautions to slowly inject the gas after the air–gas exchange. (Am J Ophthalmol 2020;219: 163–169. © 2020 Elsevier Inc. All rights reserved.)

THE ESTIMATED ANNUAL INCIDENCE OF RHEGMATOGenous retinal detachments (RRDs) is between 6 and 18 per 100,000 population, with a growing incidence in the aging population.[1] Pars plana vitrectomy (PPV) is the most common RRD repair procedure among commercial insured and Medicare-insured patients in the United States with trends showing a concurrent decline in scleral buckling.[2,3] The rise in the use of PPV over the past decade has been attributed to several influences, including technical advances, decreases in surgical times, and training characteristics of vitreoretinal surgical fellows.[3] Improvements in PPV techniques involving small-gauge instrumentation and suture-less surgery, high-speed cut rates, and wide-angle viewing systems have contributed to the rise in PPV procedures, accounting for nearly 60% of all repairs.[3] Recent claims-based analyses confirm that PPV accounts for the majority of all RRD repairs and are driven by patient-level and physician-level factors and less by geographic variation.[4]

There are reports of unexplained vision loss after PPV, unrelated to preoperative retinal pathology, despite favorable anatomic results. Suspected etiologies have included retinal toxicities, vascular events, forceps-related direct retinal injury, and optic neuropathies.[5] Peripheral visual field defects have been reported after PPV for macular hole repair[6-10] and suspected due to elevated infusion air pressure.[11,12] We characterize a novel complication involving paracentral visual scotomas after uncomplicated RRD repair involving small-gauge PPV.

METHODS

THE MEDICAL RECORDS OF 9 PATIENTS WHO REPORTED paracentral and cecocentral scotomas after PPV for RRDs by a single surgeon (RNK) from January 2013 to December 2018 were retrospectively reviewed. This study was

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TABLE 1. Visual Scotomas After Pars Plana Vitrectomy for Rhegmatogenous Retinal Detachment

Patient No.	Age, Years	Gender	Medical History	Ocular History	RD History	Preopeartive Vision	Eye	Macula Status	Gauge	Surgical Intervention	Scotoma Noticed	Scotomas on HVF	Ganglion Cell Loss Superior Nasally	Vision 6 Months After RRD Repair
1	62	M	None	Pseudophakia	None	20/20	Right	Macula spared	23-g, valved	PPV/PFO/ AFX/ Endolaser/ 14% C3F8	Postoperative week 1	Central on 24-2; inferior temporal paracentral scotoma	Yes	20/20
2	64	M	Hypertension, prostate cancer	Corneal transplant, pseudophakia	Pneumatic retinopexy	20/25	Right	Macula spared	23-g, valved	PPV/PFO/ AFX/ Endolaser/ 14% C3F8	Postoperative day 1	Central on 10-2; deep inferior cecocentral scotoma respecting horizontal midline	Yes	20/25
3	51	M	Hypertension	Pseudophakia	Laser retinopexy	20/20	Right	Macula spared	23-g, valved	PPV/PFO/ AFX/ Endolaser/ 14% C3F8	Postoperative week 1	Central on 10-2; inferior cecocentral scotoma respecting horizontal midline	Yes	20/20
4	53	F	Hypothyroidism	Pseudophakia	None	20/25	Right	Macula spared	23-g, valved	PPV/PFO/ AFX/ Endolaser/ 14% C3F8	Postoperative month 1	Central on 10-2; inferior temporal scotoma respecting horizontal and vertical meridians	Yes	20/25
5	57	M	Hypertension	None	Pneumatic r etinopexy	20/20	Right	Macula spared	25-g, valved	PPV/AFX/ Endolaser/ 20% SF6	Postoperative week 1	Central on 10-2; narrrow, deep inferior cecocentral scotoma along the inferior aspect of the horizontal meridian	Yes	20/20

Continued on next page

TABLE 1. Visual Scotomas After Pars Plana Vitrectomy for Rhegmatogenous Retinal Detachment (*Continued*)

Patient No.	Age, Years	Gender	Medical History	Ocular History	RD History	Preopeartive Vision	Eye	Macula Status	Gauge	Surgical Intervention	Scotoma Noticed	Scotomas on HVF	Ganglion Cell Loss Superior Nasally	Vision 6 Months After RRD Repair
6	69	F	None	None	None	20/40	Right	Macula involved	23-g, valved	PPV/AFX/ Endolaser/ 20% SF6	Postoperative week 1	Central on 10-2; deep paracentral inferior scotoma with extension above the horizontal meridian	Yes	20/100
7	71	F	None	None	Pneumatic retinopexy	20/40	Right	Macula spared	23-g, valved	PPV/PFO/ AFX/ Endolaser/ 20% SF6	Postoperative week 1	Central on 10-2; dense inferior cecocentral scotoma extending above and below the horizontal midline	Yes	20/200
8	66	M	Asthma	Pseudophakia	None	20/80	Right	Macula involved	23-g, valved	PPV/PFO/ AFX/ Endolaser/ 14% C3F8	Postoperative week 1	Central on 24-2; inferior temporal paracentral scotoma	Yes	20/25
9	56	M	None	None	PPV	20/30	Right	Macula spared	23-g, valved	PPV/AFX/ Endolaser/ 20% SF6	Postoperative month 1	Central on 24-2; inferior cecocentral scotoma respecting the horizontal and vertical meridians	Yes	20/30

C3F8 = perfluoropropane; F = female; M = male; PFO = perfluorooctane; PPV = pars plana vitrectomy; RD = retinal detachment; SF6 = sulfur hexafloride.

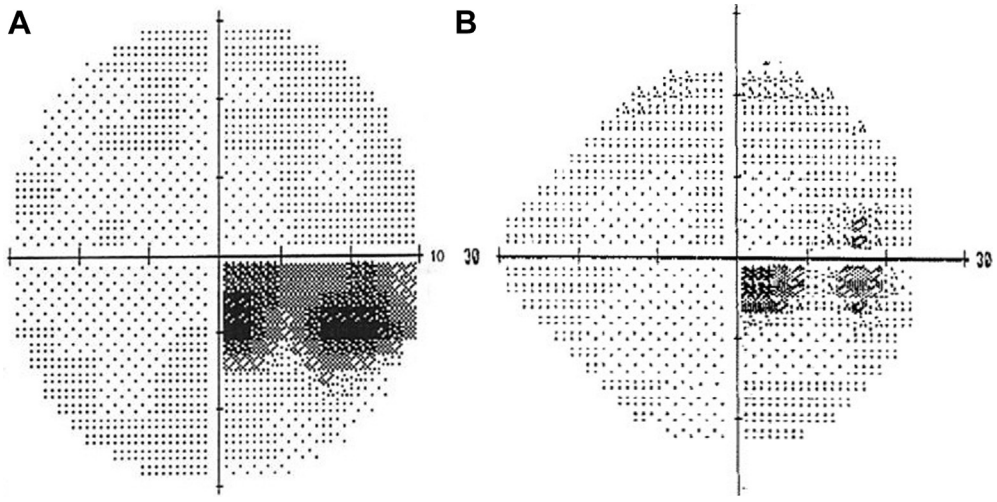

FIGURE 1. Central scotomas after pars plana vitrectomy for rhegmatogenous retinal detachment repair. (A) 10-2 Humphrey visual field results of the right eye show a discrete deep inferior cecocentral scotoma, with complete respect for the horizontal midline. (B) 24-2 Humphrey visual field results show an inferior paracentral scotoma with extension toward the blind spot.

approved by the institutional review board at the El Camino Institutional Review Board (Mountain View, California, USA) and conformed to the tenets of the Health Insurance Portability and Accountability Act and Declaration of Helsinki for research involving human subjects.

Clinical information including age, gender, medical history, ophthalmic examination findings, and intraoperative data were obtained from medical records. All patients underwent detailed ophthalmic examination before and after surgery. Multimodal imaging involving fundus photography, fluorescein angiography, autofluorescence, and spectral-domain optical coherence tomography (OCT; Cirrus, Carl Zeiss Meditech, Dublin, California, USA; Spectralis, Heidelberg Engineering, Heidelberg, Germany) including ganglion cell analysis were reviewed. Automated 10-2 and/or 24-2 Humphrey visual fields were also reviewed for all patients. The number of PPV performed for RRDs were determined by examining billing codes for PPV for RRD from January 2013 through December 2018 by single surgeon (RNK).

• **SURGICAL PROCEDURE:** All patients underwent either 23- or 25-gauge PPV (Constellation; Alcon Laboratories Inc., Fort Worth, Texas, USA) with valved cannulas using a wide-angle viewing system (Resight; Carl Zeiss Meditech) by a single surgeon (RNK). Retrobulbar anesthesia with a combination of lidocaine 2% and bupivacaine 0.75% was performed. Intraocular pressure control setting was switched on and set at a pressure of 25 mm Hg. Core vitrectomy after the confirmation of or creation of a posterior vitreous detachment was performed followed by peripheral vitreous shaving with scleral indentation. The pre-existing retinal breaks were marked with diathermy and fluid–air exchange performed with subretinal fluid drainage from the retinal breaks. The use of perfluorocarbon or drainageretinotomy was also done as needed. Laser photocoagulation was then performed around retinal breaks or drainage retinotomies. Nonexpansile concentrations of sulfur hexafloride (20%) or perfluoropropane (14%) were prepared with a 60-cc syringe and connected to the inferotemporal infusion cannula. Using a vent (Alcon Laboratories Inc.) placed on the superotemporal valved cannulas, the nonexpansile gas was then exchanged by manual injection of the gas. Sclerotomies were checked and scleroconjunctival closures were applied when needed.

RESULTS

NINE PATIENTS REPORTED VISUAL SCOTOMAS AFTER PPV for RRD (Table 1) with an incidence of 6.4% (9/140). The average age was 61 years (range 53-71 years), and 3 of 9 were female. None of the patients had a diagnosis of primary open angle glaucoma or glaucoma suspected at the time of surgery. The preceding RRD was macula-sparing for 7 of 9 patients, and all of them involved the right eye. Four of 10 patients had no previous procedures while 1 patient had a laser retinopexy, 3 had a pneumatic retinopexy, and a 1 had a previous PPV. Eight patients had 23-gauge PPV while 1 patient had 25-gauge PPV.

Seven of 9 patients reported the central scotoma within the first week after surgery. All 9 patients noted paracentral or cecocentral location of scotomas involving the inferior temporal visual field (Figure 1). Multimodal imaging was only significant for corresponding focal superior nasal ganglion cell loss on spectral-domain OCT for all 9 patients (Figure 2), demonstrating a strong structure–function correlation. Two of 9 patients had symptomatic visual loss from the scotoma as it involved the center of fixation. In

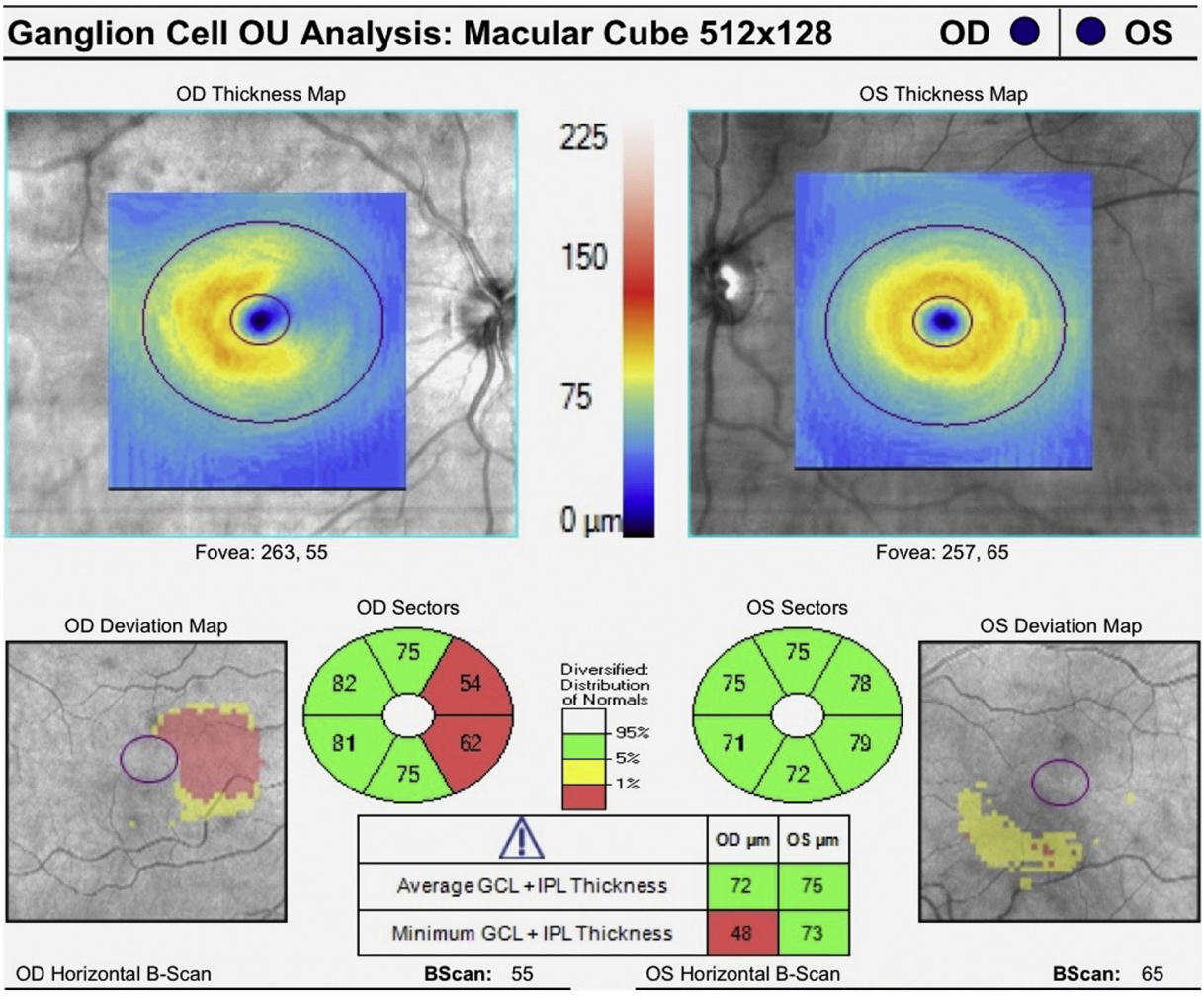

FIGURE 2. Ganglion cell loss after pars plana vitrectomy for rhegmatogenous retinal detachment repair. Spectral-domain optical coherence tomography scan of the ganglion cell layer (GCL) shows a focal area of loss in the right eye in the superonasal area of the macula, corresponding to the patient's visual field loss shown in Figure 1. There is reduced thickness in this area seen on the thickness and deviation maps of the right eye. IPL = inner plexiform layer; OD = oculus dexter; OS = oculus sinister; OU = oculus uterque.

these 2 patients—6 and 7 in Table 1—visual acuities pre-RRD repair were 20/80 and 20/40, and acuities 6 months post-RRD repair were 20/100 and 20/200, respectively. Multimodal imaging was otherwise unremarkable except for ganglion cell analysis on spectral-domain OCT. There was no evidence of retinal toxicity, vascular events, or optic nerve dysfunction in all 9 cases. There was no mention of elevated intraocular pressure during the surgery and no episodes of elevated intraocular pressure (>21 mm Hg) in the postoperative period.

DISCUSSION

WE DESCRIBE A NOVEL CENTRAL/PARACENTRAL VISUAL field defect after PPV for uncomplicated small-gauge RRD repair in 9 patients. The visual field location of the scotoma is inferotemporal and is highly correlated with the superonasal location of ganglion cell loss on spectral-domain OCT. The majority of these cases involved macula-sparing RRDs, and patients noticed these scotomas within the first week postsurgery. Two patients suffered central visual loss as the scotomas involved the center of fixation.

Despite successful anatomic outcomes with PPV for RRD repair, there are reports of unexplained visual loss, including retinal toxicity, vascular events, and optic neuropathies.[5] Despite extensive imaging involving fluorescein angiography, autofluorescence, and standard spectral-domain OCT (full-thickness macular and retinal nerve fiber layer analyses), no abnormalities were noted on these modalities for all patients in this series. The

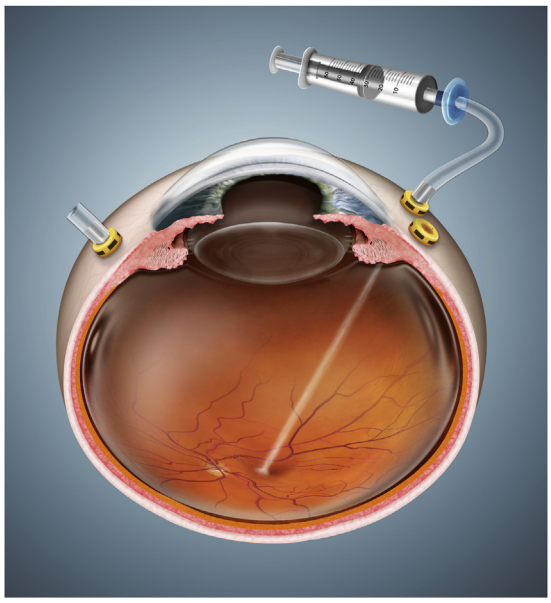

FIGURE 3. Schematic diagram showing an air jet stream from the infusion cannula. In an air-filled eye, with a vent in place, when the gas is injected quickly through a 60-cc syringe using a small-gauge cannula in the inferior temporal location, it could theoretically create an air jet stream and strike the superior nasal area of the macula.

patients all described a paracentral or cecocentral scotoma that was confirmed on 10-2 HVF testing. Cecocentral scotomas extend contiguously from central fixation to the physiologic blind spot, and usually represent an insult to the cluster of retinal ganglion cells in the nasal papillomacular bundle. Each scotoma in this series localizes to a focal defect in part of the nasal papillomacular bundle just superior to the horizontal raphe. The precise anatomic location of ganglion cell loss is well visualized using OCT imaging of the ganglion cell layer. Patients who complain of scotomas after PPV should have both 10-2 HVF testing along with OCT ganglion cell analysis.

Peripheral fields defects were initially reported after macular hole repair with PPV in 1995.[6] Subsequent work suggested that the dehydration injury to the retina in the path of pressurized air flow from the infusion cannula was the etiology of the peripheral visual defects,[13] while Hirada and associates[11] noted that the use of humidified air and the reduction of infusion air pressure from 50 mm Hg to 30 mm Hg greatly reduced the incidence of visual field defects. The infusion air might cause both dehydration injury and direct mechanical damage to the contralateral region of the retina. In their series, the arcuate visual field defects after macular hole surgery were more peripherally located, in contrast to the paracentral and central scotomas reported in our series. The scotomas in our series may have been smaller and more discrete that those reported previously because of changes in technology over the past 20 years. In the 1990s, most vitrectomies were performed using 20-gauge systems, requiring larger bore infusion cannulas than currently used in 23- and 25-gauge systems. Therefore, with larger gauge systems one would expect the column of injected air to also be wider, potentially leading to a broader area of retinal injury than observed using newer, small-gauge technologies. Consistent with this thought is the apparent trend toward a reduction in frequency of reported scotomas with smaller gauge systems. The smaller diameter of the 23- and 25- gauge cannula means a higher velocity of air stream for a given flow, as would be predicted by Poiseuille's law. Accordingly, one may theoretically expect an *increase* in incidence of focal retinal injury with smaller-diameter infusion systems, but such a trend has not been reported. Mitigating factors may include improvements in valve and canula technology (venting) and more robust intraocular pressure sensors as technology has improved over the years. Another factor may be underreporting, because the performance of formal visual fields and OCT ganglion cell analyses are not routine practice after vitrectomy in most clinics.

In this series, the visual field location of the paracentral scotoma is inferotemporal, and consistent with anatomic GC loss on spectral-domain OCT in the superonasal macula. The visual field defect and corresponding anatomic GC loss suggests a focal retinal injury. We propose that it could be caused by trauma from air flow from the infusion cannula placed inferotemporally, angled directly toward the superior nasal paracentral retina. With the infusion cannula placed inferotemporally in most cases, damage to the retina from air infusion is usually seen as whitening of the retina in the superonasal quadrant. In this series, no whitening was observed postoperatively but the presence of gas may have limited the view.

We propose that the technique of the air gas exchange involving the vent may have contributed to this retinal injury. When inserted in the valved cannula, the vent allows for passive egress of air while the gas is being administered in the eye. However, it also allows for less resistance when exchanging the gas during air–gas exchange. With decreased resistance, the gas maybe injected more quickly with the 60-cc syringe, creating a high-flow air jet stream through the small gauge cannula, which could cause focal damage to the macula (Figure 3). Interestingly, all 9 cases of paracentral scotomas involved the right eye. The surgeon uses his dominant right hand to push the gas with the 60-cc syringe when operating on right eyes, which may have unintentionally led to a more rapid injection of the gas into the eye, creating a high-flow air jet stream. To better control the egress of the air–gas mixture, we recommend injecting the gas more slowly. Alternatively, using 0.12 forceps in the valve cannula would allow for a slower egress of air from the cannula, creating more resistance, leading to a slower air jet stream from the infusion. A special infusion cannula that scatters the air infusion could also reduce the risk of focal retinal damage.[14] After

using the 0.12 forceps in the valve cannula to allow for a slower egress of air during the air–gas exchange in the 26 PPVs for RRDs, none of the patients reported a paracentral scotoma.

The incidence of paracentral or cecocentral scotomas after PPV for RRD was 6.4% (9/140) in this series. This estimate and report have many limitations, including a selection bias as only patients who complained of scotomas were included and HVF testing was not done after all RRD repairs. Furthermore, the incidence of such scotomas may be even higher as the majority of patients within our series had good central vision (macula-sparing RRD) while those with macula involving RRDs may have experienced this but did not report the scotoma because of the compromised vision. Another limitation is that only automated HVF were used instead of Goldman Perimetry—the latter modality may be able to more fully characterize the peripheral extent of the scotomas.

In summary, we describe paracentral and cecocentral scotomas after PPV for uncomplicated small-gauge RRD repair in 9 patients. The location of the scotomas in the inferior temporal visual field is consistent with ganglion cell loss imaged in the superior nasal macular area. The anatomic loss of the ganglion cell layer is consistent with possible trauma from air flow from the infusion cannula. Surgeons should be aware of this complication and take precautions to slowly inject the gas during the air–gas exchange.

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