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ORIGINAL ARTICLE

Clinical Utility of Ultra-Widefield Imaging with the Optos Optomap Compared with Indirect Ophthalmoscopy in the Setting of Non-Traumatic Rhegmatogenous Retinal Detachment

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ABSTRACT

Purpose: To evaluate the clinical utility of ultra-widefield imaging as an adjunctive tool in the diagnosis, management, and follow-up of eyes with non-traumatic rhegmatogenous retinal detachment. *Methods*: Retrospective chart review of patients with a rhegmatogenous retinal detachment who received ultra-widefield imaging with the Optos® Optomap® P200Tx. Comparisons were made between UWF imaging and indirect ophthalmoscopy for features of detachments, including extent of detachment, holes, retinopexy, and related pathology. *Results*: Thirty-six eyes of 34 patients were included. Preoperatively, ultra-widefield imaging more precisely documented the extent of retinal detachments in the superior, inferior, and nasal quadrants in 13.9% of cases. Ultra-widefield imaging failed to detect retinal holes in the superior and inferior quadrants in 11.1% and 19.4% of cases, respectively. In postoperative imaging, UWF photos did not detect retinopexy which was ophthalmoscopy-visible both superiorly and inferiorly in 19.4% of cases. The mean differences in clock hours of the detachments as documented on the clinical exam compared to ultra-widefield imaging in the superior, inferior, temporal, and nasal quadrants were -0.18 ± 0.84, 0.41 ± 1.16, 0.08 ± 1.08, and -0.13 ± 2.25 hours, respectively. *Conclusion*: Ultra-widefield imaging is a useful adjunct for documentation of rhegmatogenous retinal detachments and their postoperative repair. However, detection of retinal holes, tears, and postoperative scarring is poor, especially in the inferior and superior periphery.

Keywords: Optomap, optos, retinal imaging, rhegmatogenous retinal detachment, ultra-widefield imaging

INTRODUCTION

Ultra-widefield (UWF) imaging is a rapidly evolving diagnostic modality with the ability to image peripheral retinal pathology to a greater extent than traditional fundus photography. The ability to image a 200° field of the retina in a single image has important implications for the diagnosis, treatment, and follow-up of a variety of vitreoretinal disorders, including diabetic retinopathy,[1–3] sickle cell retinopathy,[4] retinal vascular occlusions,[5,6] uveitis,[7] and retinopathy of prematurity[8] among others.[9] However, UWF imaging systems and scanning laser ophthalmoscopes such the Optos® Optomap® have limitations, including an inability to image the entire periphery to the ora serrata, a red/green pseudocolor rather than the traditional color image, and a theoretically lower posterior pole resolution than traditional fundus

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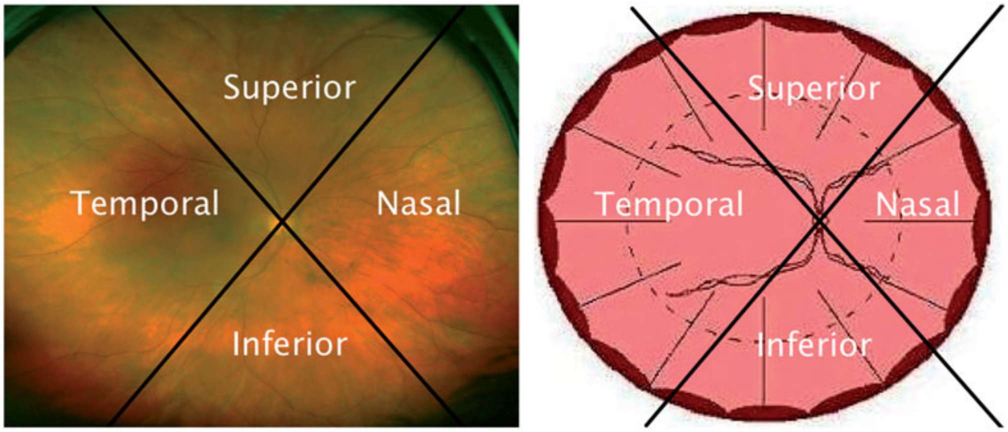

FIGURE 1. Fundus drawings and UWF images were partitioned into four quadrants, and all retinal pathology was categorized by the predominate quadrant of pathology.

photography.[9] Nevertheless, the Optos® UWF imaging system has proved to have high sensitivity and clinical utility for detecting pathology throughout the fundus, including the posterior pole.[10,11]

A dilated fundus examination with binocular indirect ophthalmoscopy remains the gold standard for diagnosis and documentation of retinal pathology. However, properly documenting the location and extent of retinal detachments, retinal tears, and other retinal pathology with binocular indirect examination can be problematic when dealing with patients with recurrent retinal detachments or other complex conditions. In complicated cases, physicians may concentrate on documenting the more severe aspects of the retinal disease while not focusing on other pathology that may be important on long-term follow-up.[12] Moreover, fundus drawings are limited, especially in the era of electronic medical records, and drawing a two-dimensional representation of the spherically shaped retina will always create topographical misrepresentations.

UWF imaging may have a role in not only assisting with the diagnosis of rhegmatogenous retinal detachments (RRD), but also with improving the documentation of RRDs and other retinal pathology. Additionally, UWF imaging may help with monitoring clinical progression as well as surgical planning. By comparing preoperative and postoperative Optos® UWF images to the dilated clinical exam (as noted in the fundus drawings), the primary goal of this study was to critically evaluate the clinical utility of ultra-widefield imaging as an adjunctive tool in the diagnosis, management, and follow-up of eyes with non-traumatic rhegmatogenous retinal detachment.

METHODS

This was an Institutional Review Board (IRB) approved retrospective study of consecutive patients who presented with a non-traumatic rhegmatogenous retinal detachment to Weill Cornell Medical Center/NewYork-Presbyterian Hospital between January 1, 2010, and October 1, 2013, and underwent surgical repair. The inclusion criteria were Optomap® 200Tx UWF imaging (pseudocolor with red/green laser) having been performed at the time of the RRD and follow-up imaging taken within one year of having the detachment surgically repaired. Patients who had multiple retinal surgeries between the period of the two images or who had proliferative diabetic retinopathy with tractional retinal detachments, exudative retinal detachments, or other complex retinal pathology were excluded from the analysis.

All UWF images of preoperative and postoperative cases were divided into four quadrants: superior, inferior, nasal, and temporal (Figure 1). Two reviewers compared pathological findings seen in each quadrant of the UWF image to the findings noted on the fundus drawing and clinical assessment. All instances were recorded where UWF imaging indicated a more accurate extent of the retinal detachment or more accurately localized retinal holes, tears, postoperative retinopexy, or other retinal pathology. Pathology and postoperative retinopexy that was visible by ophthalmoscopy as documented on the clinical exam but which UWF imaging failed to detect were also recorded.

Preoperative pathology was separated into categories: retinal detachments, holes and tears, and other relevant peripheral pathology, including scars, lattice degeneration, vitreous debris, retinal edema, and retinal hemorrhages. Postoperative retinopexy included retinal scarring from holes, tears, or from retinotomies and retinectomies. The retina was examined in the postsurgical UWF images to ensure repair of the RRD could be detected. The type of retinal detachment repair, including scleral buckle, pars plana vitrectomy, or a combination, was also noted.

TABLE 1. Demographics.

Procedure	Eyes	Right eyes	Mean age ± SD	Males	Recurrent RD	Macula involving
PPV	24	10	59 ± 15	14	15	19
SB	6	2	32 ± 13	2	1	1
PPV & SB	6	4	65 ± 12	3	1	4
Total	36	20	55 ± 18	15	17	24

Abbreviations: PPV, pars plana vitrectomy; SB, scleral buckle.

TABLE 2. Primary quadrant of the rhegmatogenous retinal detachments by procedure.

	Primary quadrant of detachment				
Procedure	Complete	Superior	Inferior	Temporal	Nasal
PPV	6	6	5	4	3
SB	0	2	3	1	0
PPV & SB	2	3	0	1	0
Total	8	11	8	6	3

The clock hours of the retinal detachments were compared between the UWF images and as documented by the clinical examinations. The actual beginning clock hour of the detachment was determined from the UWF image and was subtracted from the clock hour as recorded on the clinical assessment. The difference between the ending clock hours of the retinal detachment was similarly calculated. Each RRD was categorized by quadrant. Wilcoxon signed rank tests were conducted to determine if the difference in RRD clock hours between the clinical exam and UWF image in each quadrant significantly varied from zero. A Kruskal-Wallis test was performed to compare the mean difference in clock hours in each quadrant. All means are ± 1 standard deviation.

RESULTS

Thirty-four patients were included in the analysis. One patient had retinal detachments in both eyes, and one patient had two separate retinal detachment repair procedures in the same eye for a total of 36 cases. Demographics of the patients are shown in Table 1. The primary quadrant where the RRDs occurred is shown in Table 2.

A comparison of visualization of the retinal detachment and accompanying pathology between ophthalmoscopic examination and UWF imaging was conducted. Table 3 summarizes cases preoperatively and postoperatively where UWF images allowed a more accurate localization and detection of the extent of pathology compared to ophthalmoscopy as documented on the clinical exam, and also summarizes cases where UWF failed to detect pathology which could be seen on the clinical exam. Representative

TABLE 3. Comparison of UWF imaging to ophthalmoscopic examination in accurately detecting the extent and location of pathology for cases preoperatively and postoperatively.

	Improved detection with UWF (cases)	%	Undetectable by UWF (cases)	%
Retinal detachments				
Superior	5	13.9	0	0.0
Inferior	5	13.9	3	8.3
Temporal	1	2.8	1	2.8
Nasal	5	13.9	1	2.8
Retinal tears & holes				
Superior	1	2.8	4	11.1
Inferior	0	0.0	7	19.4
Temporal	1	2.8	1	2.8
Nasal	2	5.6	0	0.0
Other pathology*				
Superior	0	0.0	3	8.3
Inferior	1	2.8	3	8.3
Temporal	2	5.6	1	2.8
Nasal	0	0.0	1	2.8
Postsurgical retinopexy†				
Superior	1	2.8	7	19.4
Inferior	2	5.6	7	19.4
Temporal	3	8.3	1	2.8
Nasal	1	2.8	0	0.0

*Includes scars, lattice, debris, edema, and hemorrhages.
†Includes retinal scars, retinotomies, and retinectomies.

images where UWF imaging allowed a more accurate localization of pathology compared to the fundus drawing are shown in Figure 2.

In 13.9% of cases, UWF imaging more precisely documented the extent of the retinal detachment in the superior, inferior, and nasal quadrants compared to the clinical exam. In 8.3% of cases, the UWF photo did not fully display the retinal detachment inferiorly (Figure 3A). Any macula involvement as determined by clinical exam was always similarly seen on UWF imaging.

For retinal holes and tears, in 5.6% of cases preoperatively, UWF imaging either detected additional holes or tears or more precisely showed the extent or location of this type of pathology in the nasal quadrant compared to the clinical exam. In contrast, superiorly and inferiorly, in 11.1% and 19.4% of cases, respectively, there were ophthalmoscopy-visible holes or tears which were undetectable by UWF (Figure 3B). An example of UWF imaging failing to capture pathology in the inferior quadrant is shown in Figure 4. Scars, lattice, debris, edema, and hemorrhages were UWF-detectable but not visible by ophthalmoscopy in 5.6% of cases in the temporal quadrant. In comparison, 8.3% of cases in both the superior and inferior quadrants had ophthalmoscopy-visible lesions of this type of pathology but which were undetectable by UWF (Figure 3C).

When examining postoperative cases, UWF imaging indicated a more accurate extent of postsurgical

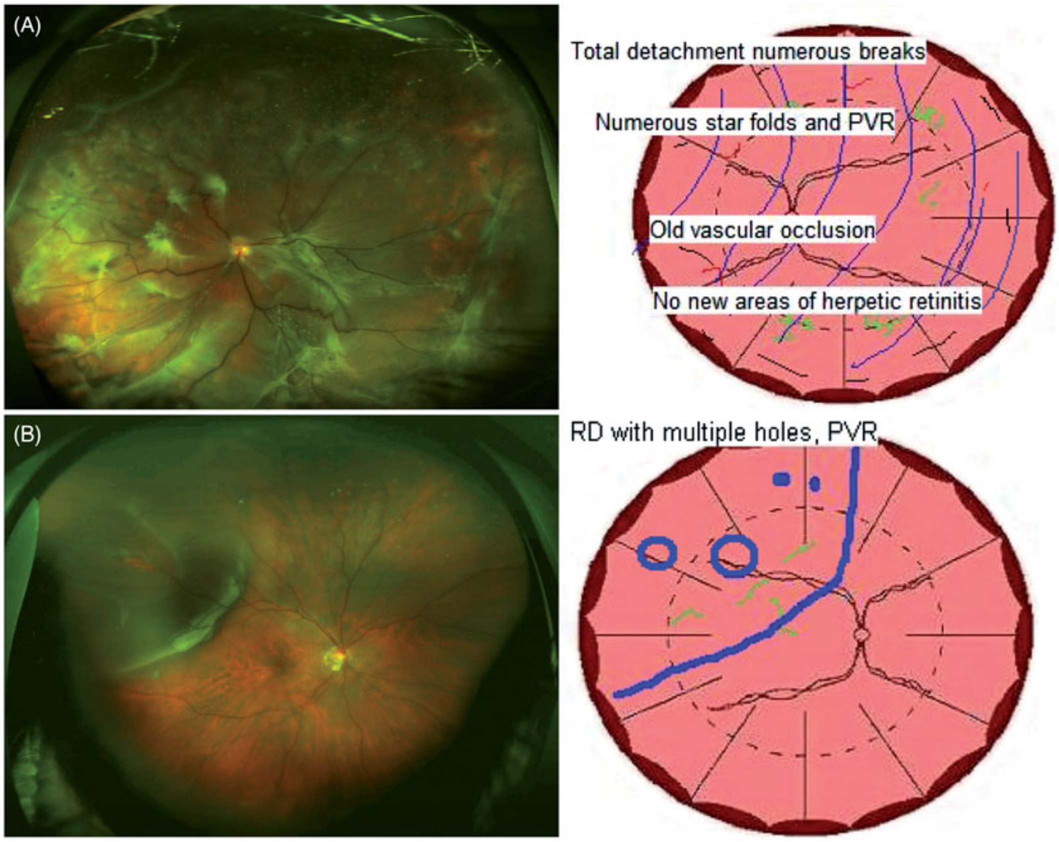

FIGURE 2. Representative UWF images of cases where UWF more accurately portrays retinal pathology than the associated fundus drawings. (A) Precise recording of the pathology in this case is problematic due to the large number of breaks, making the UWF image helpful in documentation. (B) UWF more accurately shows the extent of the RRD superiorly than as seen on the fundus drawing.

retinopexy compared to ophthalmoscopy in 5.6% and 8.3% of cases in the inferior and temporal quadrants, respectively. In contrast, UWF was unable to detect retinopexy which was ophthalmoscopy-visible both superiorly and inferiorly in 19.4% of cases in UWF imaging (Figure 5A). When including only detachments that were primarily superior, in 9.1% of these cases UWF imaging indicated a more accurate extent or detection of temporal retinopexy. Conversely, 36.4% and 27.3% of primarily superior detachments had retinopexy in the superior and inferior quadrants, respectively, which was undetectable by UWF (Figure 5B). When including only detachments that were primarily inferior, 25.0% of these cases had UWF imaging that showed a more accurate extent of retinopexy inferiorly, and in 12.5% of cases UWF was not able to detect retinopexy inferiorly compared to the clinical exam (Figure 5C). An example of preoperative and postoperative UWF images of a repair of a retinal detachment is presented in Figure 6.

The deviations between the actual beginning and ending clock hours of the retinal detachments as seen on UWF were compared to the clock hours documented from the clinical exam for detachments in each quadrant. The mean differences in clock hours of the detachment for the clinical exam and UWF imaging in the superior, inferior, temporal, and nasal quadrants were -0.18 ± 0.84, 0.41 ± 1.16, 0.08 ± 1.08, and -0.13 ± 2.25 hours, respectively (Figure 7). The difference in clock hours between clinical exam and UWF imaging did not significantly vary from zero in any quadrant (superior: $p = 0.31$; inferior: $p = 0.23$; temporal: $p = 0.64$; nasal: $p = 0.99$). The mean difference in clock hours between each quadrant was similar ($p = 0.31$). The mean difference in clock hours from all quadrants combined was 0.03 ± 1.09 hours.

DISCUSSION

The Optomap has previously been found to have good sensitivity for detecting retinal detachments, and these results are in agreement with our data. In a prospective study by Khandhadia et al. of 219 patients who presented to an ophthalmology department, seven retinal detachments were detected by a masked ophthalmologist, and an independent reviewer of the Optomap images also detected all seven detachments.[10] A separate study by Bonnay et al. found that of the patients referred to a retinal specialist for possible detachments who were also imaged by an Optomap 200, all except two detachments, one inferior and one superior, were detected using the Optomap out of the 56 eyes diagnosed with

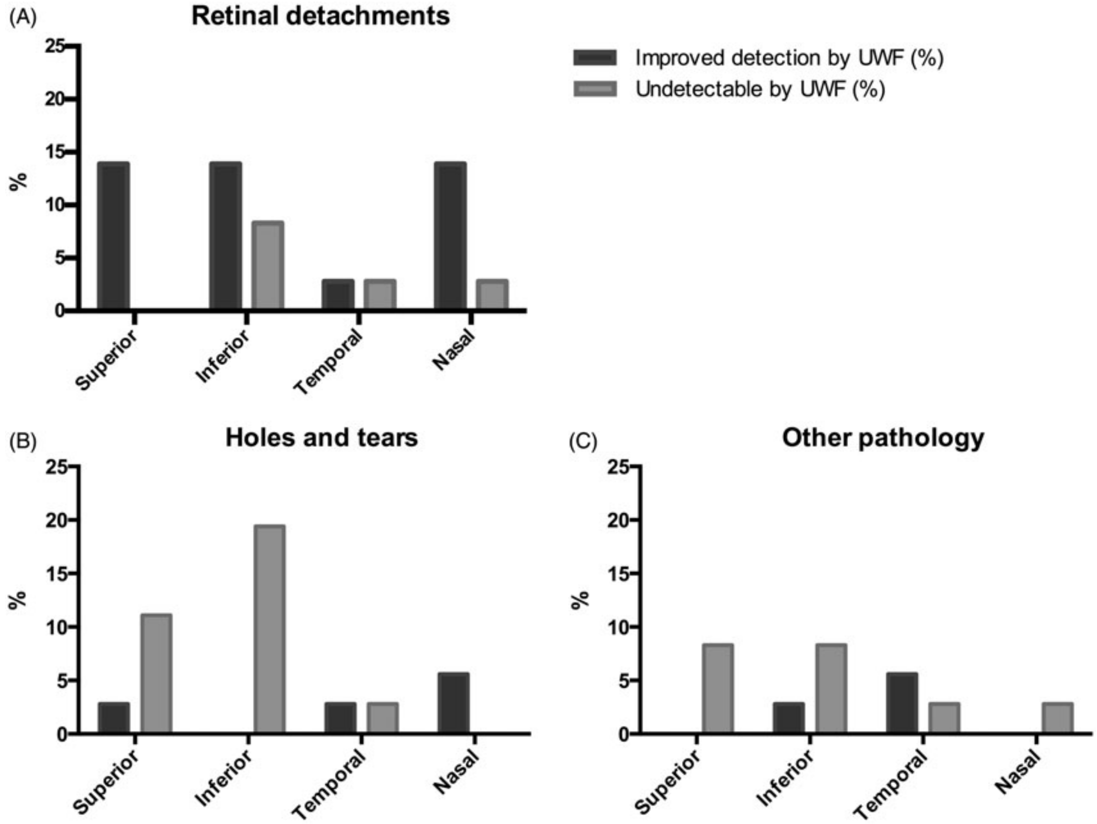

FIGURE 3. Percentage of preoperative cases with UWF imaging improving the ability to detect and localize pathology compared to indirect ophthalmoscopy, and percentage of cases with UWF-undetectable pathology.

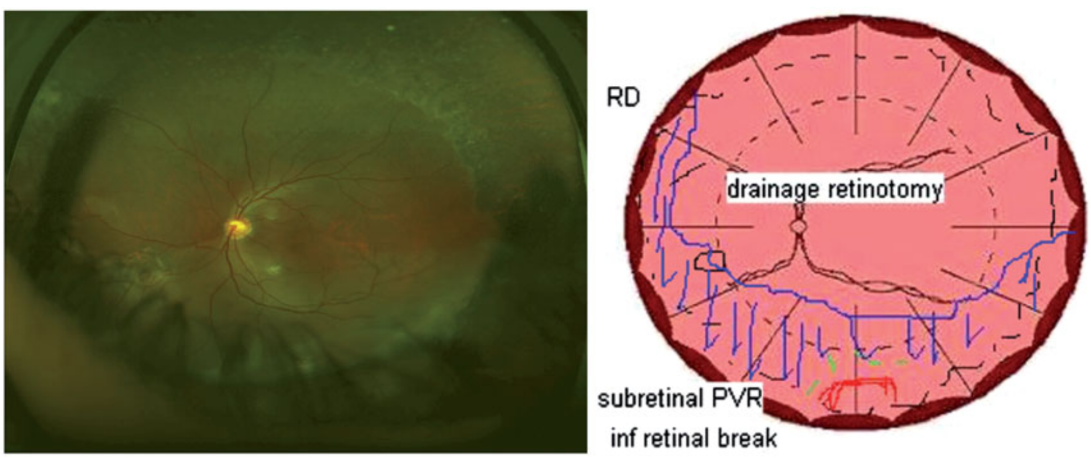

FIGURE 4. Obstruction of the inferior view due to eyelashes and difficulties in patient positioning is common. These result in inferior pathology that is poorly or not imaged at all by the Optomap, such as the inferior retinal break in this case.

retinal detachments by the specialist.[13] Lastly, Mackenzie et al. also conducted a prospective study of 52 patients referred for retinal pathology and imaged by the Optomap system. Eleven of the 12 retinal detachments diagnosed by clinical exam were also identified with the Optomap by masked reviewers.[11] Our study indicated a similar ability of the Optomap to detect RRDs. Even though UWF imaging did not fully display the inferior portion of the RRD in 8.3% of cases, in all 36 cases the detachments could be at least partially observed. We also found that UWF imaging allowed improved detection of the extent of these detachments than as documented on the fundus drawing of the clinical assessment in 14% of cases superiorly, inferiorly, and nasally. In addition, postoperative examination of UWF images was able to confirm in all cases that the retina was attached.

Our data indicate that UWF imaging effectively complements the clinical exam for documentation of

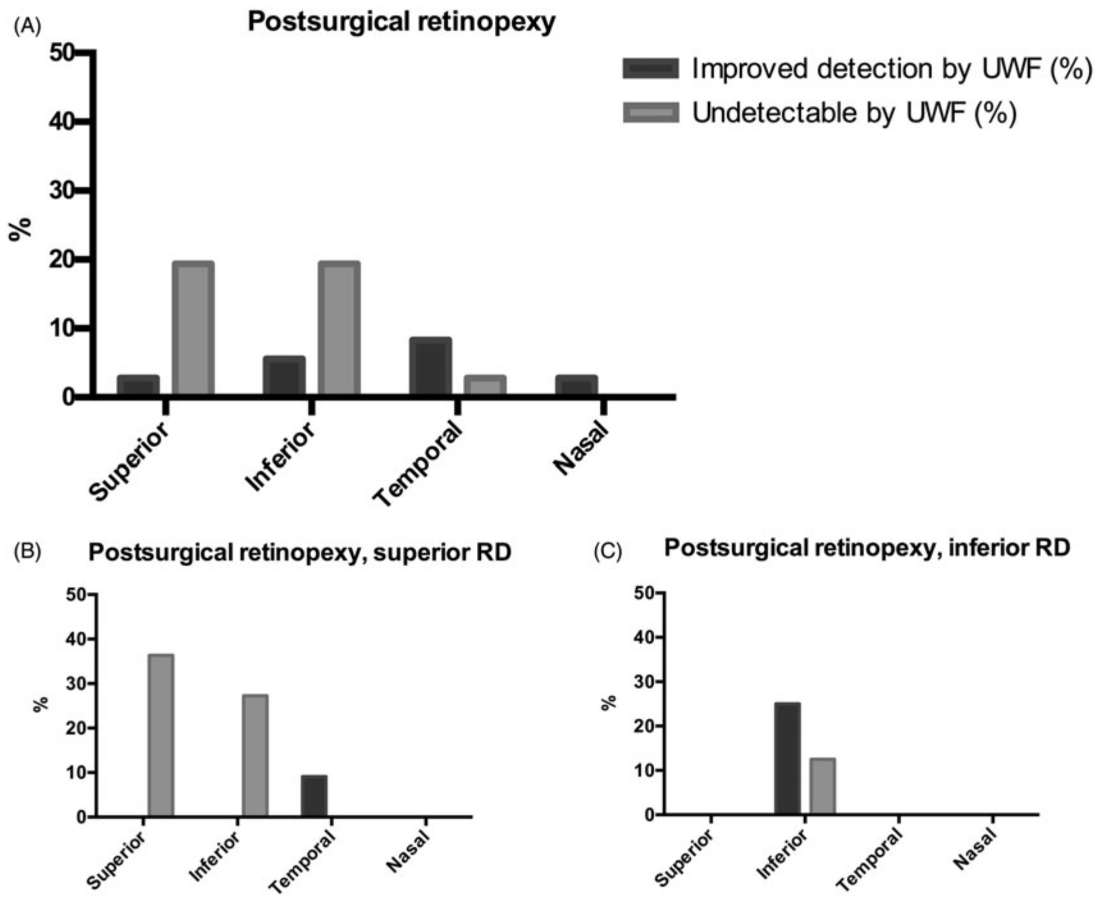

FIGURE 5. Percentage of postoperative cases with improved detection by UWF imaging of postsurgical retinopexy, and percentage of cases with undetectable retinopexy by UWF in (A) retinal detachments in all quadrants, (B) detachments only in the superior quadrant, (C) detachments only in the inferior quadrant.

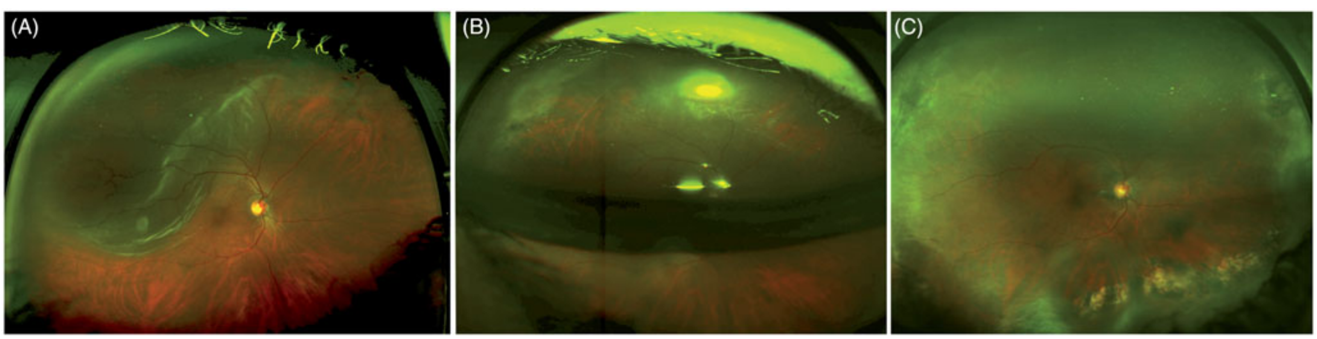

FIGURE 6. Preoperative and postoperative UWF images of a RRD repaired by par plana vitrectomy. (A) Preoperative image documents a superotemporal RRD. (B) Postoperative image five days after surgery displays the intraocular gas tamponade (SF6), but is not able to detect a choroidal detachment superiorly under the gas bubble which could be seen on binocular indirect examination. (C) Long-term follow-up seven months after initial RRD shows an attached retina and areas of scarring.

the location of retinal detachments. When comparing the clock hours of the RRD on UWF imaging to ophthalmoscopy, we found that although there was no significant difference, the average deviation of the difference between the clock hours of the clinical exam and the UWF imaging was more than one hour, with a range up to three hours. This variation in clock hour documentation indicates that UWF imaging can be used to confirm or more accurately show the extent and the location of retinal detachments in individual cases. This can have important treatment implications, particularly for preoperative planning, regardless of treatment technique, as position of scleral buckling radial elements can depend on the precise clock hour of retinal tears. Likewise, optimal placement of trochars

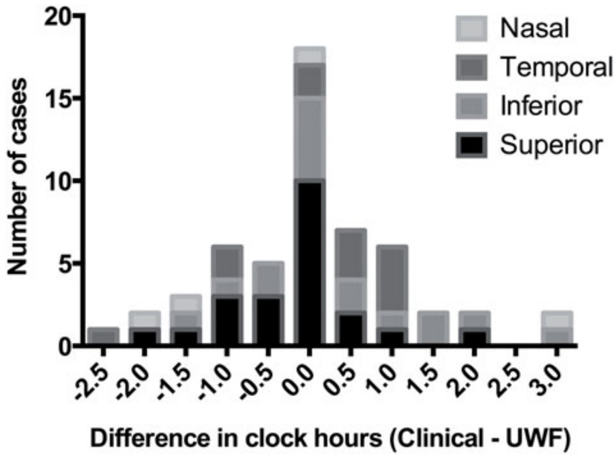

FIGURE 7. Relative difference in clock hours of the detachment as documented in the clinical exam compared to UWF imaging by quadrant of retinal detachment.

for vitrectomy cases depends on accurate clock hours of all pathology.

Although the Optomap is excellent for the detection and documentation of RRDs, we found that it may be insufficient in its ability to document retinal holes and tears, especially in the far superior and inferior quadrants. There were 11 instances out of a total of 36 cases where the clinical exam documented holes or tears in the superior or inferior quadrants that could not be seen in UWF imaging. The poor detection of retinal holes and tears is in accordance with a study done by Khandhadia et al. indicating a 33% sensitivity of the Optomap for detection of holes and tears.[10] Similarly, we found that other pathology, such as lattice, scars, and hemorrhages, could be difficult to detect using UWF imaging when in the superior or inferior quadrants. In 8.3% of cases, either superior or inferior instances of these types of pathology could not be seen on UWF imaging.

Poor imaging of the inferior quadrant may often be secondary to eyelashes obstructing the view, as seen in Figure 5. This is a problem that has been noted in multiple studies on UWF imaging.[2,10,11,14,15] Inoue et al. found that use of an eyelid speculum helped prevent obstruction by eyelashes and allowed a fuller view of the retina,[16] and Cheng et al. found that eyelid retraction using a cotton bud proved useful.[17] Proper positioning of the patient's view can also affect peripheral imaging. In our clinic, technicians who obtained the UWF photos tended to position the eye so that the retinal detachments were most visible, which on occasion was detrimental to the ability to detect pathology in other quadrants. Documentation of pathology from all quadrants may require multiple photos taken with different eye positioning.

Postoperatively, we found UWF images useful in documenting repair of RRDs. In all cases, UWF imaging was able to confirm attachment of the retina. However, similar to the poor ability to image retinal holes, tears, and other pathology in the superior and inferior quadrants, UWF imaging often failed to image retinal scarring and other outcomes of retinopexy in these same quadrants. In 19% of cases superiorly and inferiorly, UWF imaging failed to show retinal scars or retinectomies that could be seen from the clinical exam.

Peripheral imaging by the Optomap is an advancement over traditional fundus photography; however, complete imaging of the periphery and replacement of a dilated exam by the Optomap is not yet achievable. Although the Optomap has been shown to have an improved ability to image peripheral pathology compared to the ETDRS 7-standard field imaging in diabetic retinopathy,[1–3] and it also has a higher capability to image peripheral CMV retinitis lesions than conventional photography,[14] UWF still may fail to expose lesions that are in the far peripheral retina, such as the case with retinal hole and tears. Mackenzie et al. found that detection of lesions posterior to the equator had a 74% sensitivity, while detection of lesions anterior to the equator was much lower with a 45% sensitivity.[11] Khandhadia et al. similarly found a tendency for UWF to miss retinal holes and tears in the far periphery.[10] It should be noted that the ability of the UWF device to image the periphery of the retina can differ between models, as the Heidelberg Spectralis noncontact ultra-widefield module has been found to capture a wider field superiorly and inferiorly than the Optomap, although at the expense of worse nasal and temporal imaging.[18] However, the overall total retinal area imaged by the Heidelberg is significantly less than that of the Optos and, as such, even more pathology may be missed by relying on this modality alone.

In our clinic, the Optomap images may have been used in conjunction with the binocular indirect exam during the preoperative or postoperative visit to determine retinal pathology, and this limited the ability of our study to separate the differences between the clinical exam and the UWF imaging. This also therefore prevented us from calculating from calculating the sensitivity and specificity of UWF imaging. Another possible limitation of our study is that the aptitude of the technician acquiring the images can affect what pathology is visible. Some technicians tended to focus on the retinal pathology, sometimes with verbal direction by the retinal specialist, while other technicians used a central focus. Also, our study assumes that pathology indicated on the clinical exam but which could not be seen on UWF imaging was due to a failure of the Optomap to properly image the pathology rather than inappropriate assessment during the indirect binocular examination.

In summary, ultra-widefield imaging is an excellent tool and useful adjunct for documentation of rhegmatogenous retinal detachments and their postoperative repair. However, detection of retinal holes, tears, and postoperative scarring is suboptimal compared to the clinical exam, especially in the inferior and superior far periphery. Given the high prevalence of peripheral and anterior pathology, ultra-widefield imaging can supplement documentation of retinal pathology, but it cannot be used as a replacement for a binocular indirect examination.

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DECLARATION OF INTEREST

Dr. Szilárd Kiss serves as a consultant for Optos®, the manufacturer of the wide-field fundus camera used in this manuscript. The authors alone are responsible for the content and writing of this article.

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