Potential Efficiency Benefits of Nonmydriatic Ultrawide Field Retinal Imaging in an Ocular Telehealth Diabetic Retinopathy Program

Paolo S. Silva MD1,2, Jerry D. Cavallerano OD PhD1,2, Dorothy Tolls OD2, Ahmed Omar MD2,4, Komal Thakore OD2, Bina Patel OD2,3, Mina Sehizadeh OD2, Ann M. Tolson BS2, Jennifer K. Sun MD MPH1,2, Lloyd M. Aiello MD1,2, Lloyd Paul Aiello MD PhD1,2

1Department of Ophthalmology, Harvard Medical School, Boston, Massachusetts, USA
2Beetham Eye Institute, Joslin Diabetes Center, Boston, Massachusetts, USA
3New England College of Optometry, Boston, Massachusetts, USA
4Department of Ophthalmology, Faculty of Medicine, Assiut University, Assiut, Egypt

Corresponding author and reprint requests:

Paolo S. Silva, MD
Beetham Eye Institute
Joslin Diabetes Center
1 Joslin Place, Boston, Massachusetts, USA 02215
Office: +1-617-309-2554
Fax: +1-617-309-2545
Email: paoloantonio.silva@joslin.harvard.edu

Running Title: Ultrawide Field Retinal Imaging Efficiency in an Ocular Telehealth Program

Word Count: 2,656

Number of Tables and Figures: 4
Abstract

**Objective:** To compare efficiency of nonmydriatic ultrawide field retinal imaging (UWFI) and nonmydriatic fundus photography (NMFP) in a diabetic retinopathy (DR) ocular telehealth program

**Research Design and Methods:** Retrospective, comparative cohort study of patients imaged from 11/01/2011-11/01/2012. Images were evaluated for DR and diabetic macular edema (DME) using standard protocol at a centralized reading center with certified graders. Identification of DR, image evaluation time and rate of ungradable eyes were compared.

**Results:** 1,633 and 2,170 consecutive patients were imaged using NMFP and UWFI, respectively. There were no statistically significant differences between groups in age, diabetes duration, gender, ethnicity or insulin use. The ungradable rate per patient for DR (2.9% vs 9.9%, p<0.0001) and DME (3.8% vs 8.8%, p<0.0001) was lower with UWFI than NMFP. With UWFI, median image evaluation time per patient was reduced from 12.8 to 9.2 minutes (p<0.0001). The identification of patients with DR (38.4% vs 33.8%) and vision-threatening DR (14.5% vs 11.9%) was increased with UWFI vs NMFP. In a consecutive subgroup of 502 eyes of 301 patients with DR, the distribution of peripheral retinal lesions outside ETDRS fields might have suggested a more severe DR level in 9.0% (45 eyes).

**Conclusions:** In a standardized DR ocular telehealth program, nonmydriatic UWFI reduced the ungradable rate by 71% (to less than 3%) and reduced image evaluation time by 28%. DR was identified 17% more frequently after UWFI was implemented and DR peripheral lesions may have suggested a more severe DR
level in 9%. These data suggest that UWF imaging may improve efficiency of ocular telehealth programs evaluating DR and DME.
The American Telemedicine Association has published evidence-based recommendations for ocular telehealth programs for diabetic retinopathy (DR) (1). Such programs rely on the acquisition of retinal images to determine the presence and severity level of DR and diabetic macular edema (DME) (2). Retinal imaging devices are key components of any ocular telehealth program and the current gold standard to evaluate DR is mydriatic stereoscopic Early Treatment Diabetic Retinopathy (ETDRS) protocol 7-standard 30° fundus photography (1). Recently, ultrawide field retinal imaging (UWFI) scanning laser ophthalmoscopes have been shown to compare favorably with ETDRS photography (3,4). Even without pupillary dilation, UWFI allows the acquisition of more than double the total retinal surface area captured with dilated ETDRS 7-field photography. The image acquisition time with UWFI has been shown to be less than half that of ETDRS photography, even when the time for dilation is excluded (3).

Given the potential advantages of UWFI, we conducted a study to compare the efficiency of nonmydriatic UWFI and NMFP in an established, validated ocular telehealth program for DR. Measures of image evaluation time, proportion of ungradable eyes, DR identification rates and DR severity, were evaluated.

**Research Design and Methods**

The Joslin Vision Network (JVN) is an ocular telehealth program for DR developed at the Joslin Diabetes Center that has been in continuous clinical operation since 1998 (5,6). The JVN follows a strict protocol for acquiring nonmydriatic retinal images and for grading and reporting the level of DR. Early JVN programs were developed and deployed through a cooperative agreement with the US Department of
Defense and US Veterans Administration. The JVN has served as a pilot program for several of the US federally funded programs for ocular telemedicine for DR including the Indian Health Service, US Department of Defense, and the US Department of Veterans Affairs.

We reviewed the electronic records of all patients receiving JVN retinal imaging at the Joslin Diabetes Center in Boston, Massachusetts, USA from November 1, 2011 to November 1, 2012. From November 1, 2011 to March 31, 2012, all patients were imaged using lowlight adapted nonmydriatic digital fundus photography. Stereoscopic pairs of three $45^\circ$ and two $30^\circ$ retinal fields were acquired according to a prescribed protocol, which has been previously validated to compare favorably with mydriatic ETDRS 7 standard fields (7,8). From April 1, 2012 to November 1, 2012, all patients were imaged using UWFI. UWFI was acquired using a previously validated image acquisition protocol (3) of stereoscopic pairs of $100^\circ$ and $200^\circ$ retinal images for each eye using the Optos P200MA/P200C (Optos, plc, Dunfermline, Fife, Scotland, UK) (Figure 1). Both NMFP and UWFI were acquired by corresponding JVN protocol certified imagers. JVN imagers are trained to identify ungradable images at the time of imaging and images are retaken up to three times if image quality is poor. All ultrawide field images were graded following a standard validated protocol by certified and licensed eye care providers in a centralized reading center under retina specialist supervision.

The configuration of the reading stations was optimized for the particular imaging modality that was being used at that time. All NMFP were evaluated on previously described four monitor reading stations composed of two 20-inch liquid crystal display
(LCD) monitors (one to display NMFP image thumbnails and one to display the image being evaluated), one 17-inch LCD monitor to display patient records, and one 20-inch 3D capable cathode ray tube monitor for stereoscopic viewing of the images (7,8). All ultrawide field images were evaluated using dual monitor reading stations where ultrawide field images were displayed on 27-inch, color-calibrated, high-definition, LCD monitors (model VG278H Asus, Taipei, Taiwan) with Quadro 600 video cards (Nvidia, Santa Clara, CA, USA) and a secondary 20-inch monitor to display patient records.

Since there is only an indirect correlation between the three 45° fields in NMFP and the 200° and 100° fields in UWFI with the ETDRS 7 standard 30° fields, specific protocols were prospectively devised to extrapolate information from the 45°, 200° and 100° fields. These detailed protocols for evaluating UWFI and NMFP images have been previously described and have shown substantial agreement with grading of dilated 7 field ETDRS standard photography (3,7,8). Both protocols are based on the ETDRS classification and evaluate extent and severity of individual retinal lesions in comparison to ETDRS standard photographs to determine the severity of DR and DME. All images were acquired through undilated pupils. An eye was considered ungradable if there was inadequate photographic quality, or if media opacity made it impossible to determine whether DR lesions were present in the images of that eye. If one or more disc area of retina was visible in an ETDRS defined photographic field and that area was free of the characteristic, it was graded ‘no evidence’ rather than ‘ungradable.’ If the characteristic was present in the unobscured part of the field, it was estimated for the entire field. In the absence of definable lesions in the macula, no macular edema was entered even if one image of the stereo pair prevented stereoscopic reading of the macula area. The
JVN reading center provides ongoing quality assurance by reviewing approximately 10% of all patient encounters to ensure standardized reading quality across time and different readers.

Image evaluation time was calculated for each patient by reviewing the electronically recorded time that images were accessed for reading until the time when the images were saved as read.

The study design was consistent with the tenets of the Declaration of Helsinki and the Committee on Human Studies of the Joslin Diabetes Center approved the retrospective review of the data. The conduct of the study complied with the Health Insurance Portability and Accountability Act.

**Statistical Analysis**

Nonparametric analyses (Wilcoxon rank sums) were used to compare distributions of continuous variables between groups. The Chi square test was used to compare frequencies of categorical variables. When DR severity was evaluated per patient rather than per eye, the more severe level of DR and DME present in either eye was used as the severity present in the patient. If one eye was ungradable, the level of DR and DME present in the gradable eye was considered the level of DR and DME present in the patient. All analyses were performed using SAS (version 9.2; SAS Institute Inc., Carey, NC, USA).

**Results**

During the study period 7,606 eyes of 3,803 consecutive patients were evaluated. Overall, 3,266 eyes of 1,633 consecutive patients were imaged with NMFP
and 4,340 eyes of 2,170 consecutive patients were imaged with UWFI immediately thereafter. The characteristics of both groups are shown in Table 1. There were no statistically significant differences between groups in age, gender, diabetes duration, ethnicity or insulin use.

**Diabetic Retinopathy Severity and Peripheral Lesions**

We have previously demonstrated that both imaging modalities have substantial agreement with both ETDRS protocol photography and retinal specialist dilated fundus examination (3,7,8). Using NMFP, 33.8% of patients had DR and 11.9% of patients had potentially vision threatening DR (defined as moderate nonproliferative DR or worse or any level of DME). Using UWFI, the percentage of patients identified with DR and vision threatening DR was 38.4% and 14.5%, respectively (Table 1). The distribution of DR severity in all eyes is shown in Table 2.

Given the greater retinal area imaged using UWF imaging, we evaluated a subgroup of 1,516 (36.9%) consecutive eyes imaged from August 14 to November 1, 2012 to determine the extent of peripheral retinal changes outside the ETDRS field areas. (Figure 1) There were 502 eyes of 301 patients with DR in this subgroup. In this subgroup of eyes, 14.1% (71 eyes) had hemorrhages and/or microaneurysms located outside the area covered by the ETDRS imaging protocol. Although less common, venous beading (2 eyes), intraretinal microvascular abnormalities (6 eyes) and new vessels elsewhere (3 eyes) were also observed outside ETDRS fields. These peripheral findings might have resulted in assigning a more severe level of DR in 9.0% of eyes.
Retinal tears were identified by UWFI and confirmed by clinical exam in 2 eyes (0.4%), neither of which was evident using NMFP.

*Image Evaluation Time*

The median time required to evaluate retinal images using the nonmydriatic fundus photography protocol was 12.8 minutes per patient. In contrast, the UWFI had a median evaluation time of 9.2 minutes per patient, which represents a 28% reduction of image evaluation time (p<0.0001).

*Ungradable Rate*

The ungradable rate for DR and DME per patient using NMFP in this cohort was 9.9% and 8.8%, respectively. These rates are generally consistent with our previous experience utilizing this method of image acquisition (9-11). The ungradable rate for DR and DME per patient using UWFI in this cohort was 2.9% and 3.9%, respectively. With UWFI there is a reduction in the ungradable rate per patient for DR of 71% (p<0.0001) and for DME of 56% (p<0.0001). Increasing age was associated with a substantial increase in ungradable rates for both DR and DME for both modalities as shown in Table 3. Patient ungradable rates using NMFP for DR were 2.6% in patients aged less than 50 years, 10.5% in patients 50 to 70 and 24.6% in patients over 70. In contrast, when using UWFI for DR the ungradable rates were 0.9%, 2.3% and 9.0%, respectively. Results were similar for DME. In all cases, rates were lower for UWFI than NMFP. The ungradable rate per eye for DR and DME is shown in Table 2.

*Conclusions*
In ocular telehealth programs for DR, the imaging system is a critical component that directly impacts not only the ability to identify pathology, but also the efficiency and effectiveness of the telehealth program itself. Thus, technological changes to the imaging system can exert considerable influence, particularly in large scale programs. Data from this comparative cohort study suggest that the adoption of UWFI may potentially improve the efficiency of DR ocular telehealth programs by reducing ungradable rates and image evaluation times. Combined with the identification of retinal lesions that would otherwise not have been observed using standard imaging, the use of UWFI with appropriate reading center protocols might have the synergistic benefits of increased disease detection, reduced ungradable rates and shorter image evaluation times.

Based on prior reports in systematic population based DR telemedicine programs, the ungradable rate using nonmydriatic photography is approximately 20%, with a strong association for increasing ungradable images with increasing age and diabetes duration. This rate is reduced to approximately 4% with mydriasis (12). In community based programs, the reported rate of ungradable images was 13% in patients aged less than 50 years, 39% in patients between 50 to 70 and 54% in patients over 70 (13). In the current report, NMFP ungradable rate ranged from 2.6% to 24.6% over this age range (Table 3). The ungradable rate for nonmydriatic UWFI was significantly lower, ranging from less than 1% to 9%. Compared to NMFP, nonmydriatic UWFI resulted in a reduction of the ungradable rate for DR by 71% over-all, with 63% to 78% reduction across age groups. This improvement is likely in part due to the improved ability to image through small pupils and media opacities. Additionally,
stereoscopic pairs were acquired. The additional image not only provides stereoscopic information but also helps exclude imaging artifacts and permits more complete evaluation when a field is partially obscured. Furthermore, nearly three times more retinal area is visible on UWFI without the need for gaze redirection or multiple images to capture the retinal periphery. The lower ungradable rate and the increased area of the retina imaged with UWFI may account for the 17% and 23% increase in the identification of DR and vision threatening DR, respectively. In addition, peripheral lesions are identified that may suggest a more severe level of DR in 9% of eyes. This observation confirms an earlier report identifying peripheral lesions severe enough to potentially increase the severity level of DR in about 10% of eyes (14).

A potential limitation of the DR severity analyses is the comparison of imaging modalities between two cohorts of patients acquired at different times. However, this issue is minimized by evaluation of a large number of consecutive patients who were imaged over a relatively short period of time, one immediately after the other, within a single established DR telehealth program. There were no significant differences observed in the demographic characteristics between the two cohorts. Previous publications have shown consistent agreement between UWFI and dilated ETDRS photography (kappa 0.77 -0.79)(3,4). Substantial to near perfect agreement has been reported with clinical examination and agreement with the presence or absence of DR is as high as 0.95 (3,4). The kappa values for agreement with NMFP have been shown to have substantial agreement of 0.81 for ETDRS photography, 0.71 for clinical examination and the agreement with presence or absence of DR is 0.90.(8) These data suggest that both DR detection and the determination of DR severity for both UWFI and
NMFP closely correlate with both clinical exam and mydriatic ETDRS photography. Furthermore, the observation of an increased rate of DR detection with UWFI is consistent with other published studies (14).

UWFI also resulted in considerably shorter image evaluation time than NMFP (28% reduction). This finding might be attributable to improved image quality and the need to manipulate and evaluate fewer retinal images. Only 4 images per eye are evaluated using the UWFI protocol as compared to 10 images per eye with NMFP. Additionally, 27-inch high definition monitors were used to display and evaluate the ultrawide field images as compared with 20-inch monitors for NMFP. This larger monitor size potentially may have resulted in lesser need to manipulate the images since a larger magnified image could be displayed.

In large scale programs, these efficiency savings could be considerable. The JVN program evaluates over 4,000 individuals per year. In this case alone, UWFI might save 240 hours per year in evaluation time, while preventing 560 eyes ungradable for DR and identifying approximately 720 eyes with potentially more severe retinopathy than would otherwise have been recognized. Some programs dilate pupils to obtain adequate grading quality (12). In these situations, the UWFI approach might obviate the need for dilation while maintaining a comparable ungradable rate. Such an approach would be particularly beneficial in populations where the risk of angle closure is high or where access to specialized eye care is limited.

The cost effectiveness of UWFI was not evaluated in this study and remains an important consideration due to the substantial cost of current UWFI devices which can
exceed $100,000. However, given the potential benefits of a substantially lower ungradable rate, decreased image acquisition time, ease of use and increased disease detection, the higher capital outlay for UWFI devices may be offset, especially in large volume telemedicine programs. Furthermore, costs are likely to decrease over time with further technological innovations and market competition.

Another important consideration with any imaging device is the ease of image acquisition. All JVN imagers have preferred using UWFI for telemedicine as compared to the prior nonmydriatic standard field cameras. Image acquisition using the Optos 200MA and Optos 200C imagers are substantially different as compared to traditional nonmydriatic retinal cameras. The Optos does not require focusing, is not affected as much by pupil constriction after repeated images, and obtains usable images through smaller pupils.

In summary, this study demonstrates for the first time that in a large-scale, well established telemedicine program utilizing standardized image acquisition and evaluation protocols, the implementation of UWFI reduced the ungradable rate by over 71% for DR and 56% for DME to less than 3% and 4% respectively. Furthermore, compared with NMFP, image evaluation time was reduced by 28%. In addition, ultrawide field imaging identified additional peripheral retinal lesions that may suggest a more severe level of DR in 9% of eyes. Generalizing these results to other ocular telemedicine programs needs further evaluation, especially given the rigorous standardized image acquisition and evaluation protocols, and ongoing medical oversight and quality assurance utilized in the JVN environment. However, if replicated in other programs, UWFI might substantially enhance current DR telemedicine programs.
Acknowledgements:

Author Contributions: P.S.S. researched data, wrote manuscript. J.D.C. researched data, wrote manuscript. D.T. researched data, reviewed/edited manuscript. A.O. researched data, reviewed/edited manuscript. K.T. researched data, reviewed/edited manuscript. B.P. researched data, reviewed/edited manuscript. M.S. researched data, reviewed/edited manuscript. A.M.T. researched data, reviewed/edited manuscript. J.K.S. researched data, reviewed/edited manuscript, contributed to discussion. L.M.A. reviewed/edited manuscript, contributed to discussion. L.P.A. reviewed/edited manuscript, contributed discussion.

Guarantor: The authors P.S.S. and J.D.C. take full responsibility for the contents of the manuscript.

Presented in part at the Association for Research in Vision and Ophthalmology, May 7, 2013

Conflict of Interest: Supported in part by grant funding from the Amelia Peabody Charitable Fund to the Joslin Diabetes Center. One of the two Optos P200MA instruments used in this study was provided by Optos, plc (Dunfermline, Fife, Scotland, UK) to the Joslin Diabetes Center on temporary loan. No additional outside funding was received for the performance of the research presented in this report. The Joslin Vision Network technology was developed at the Joslin Diabetes Center. All the authors are employees of the Joslin Diabetes Center. No other related conflicting relationship exists for any author.
Reference List


Table 1 - Demographic characteristics of the patients imaged with nonmydriatic fundus photography and ultrawide field imaging

<table>
<thead>
<tr>
<th></th>
<th>NMFP (N = 1633 patients)</th>
<th>UWFI (N = 2170 patients)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>53.6 ± 16.5</td>
<td>54.5 ± 16.4</td>
<td>0.15</td>
</tr>
<tr>
<td>Diabetes Duration, years</td>
<td>13 ± 10.6</td>
<td>13.2 ± 11.3</td>
<td>0.72</td>
</tr>
<tr>
<td>Female Gender</td>
<td>708 (43.4%)</td>
<td>941 (43.4%)</td>
<td>1.00</td>
</tr>
<tr>
<td>White Ethnicity</td>
<td>920 (81.1%)</td>
<td>1166 (80.5%)</td>
<td>0.71</td>
</tr>
<tr>
<td>Insulin Use</td>
<td>605 (62.8%)</td>
<td>1364 (63.2%)</td>
<td>0.82</td>
</tr>
<tr>
<td>Retinopathy Present</td>
<td>501 (33.8%)</td>
<td>806 (38.4%)</td>
<td>0.0053</td>
</tr>
<tr>
<td>Vision Threatening DR</td>
<td>176 (11.9%)</td>
<td>305 (14.5%)</td>
<td>0.0257</td>
</tr>
<tr>
<td>Patient Ungradable for DR</td>
<td>161 (9.9%)</td>
<td>63 (2.9%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Data are means ± SD or N (%). NMFP, nonmydriatic fundus photography; UWFI, ultrawide field imaging; SD, standard deviation; DR, diabetic retinopathy. Patients with unspecified or undeclared ethnicity were excluded in the calculations for ethnicity; Vision threatening DR is defined as moderate nonproliferative DR or worse, proliferative DR or or any level of diabetic macular edema;
Table 2 - Distribution of diabetic retinopathy severity per eye in nonmydriatic fundus photography and ultrawide field imaging

<table>
<thead>
<tr>
<th></th>
<th>NMFP (N = 3266 eyes)</th>
<th>UWFI (N = 4340 eyes)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ungradable Eyes for DR</strong></td>
<td>406 (12.4%)</td>
<td>236 (5.4%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Ungradable Eyes for DME</strong></td>
<td>375 (11.5%)</td>
<td>309 (7.1%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Gradable Eyes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No DR</td>
<td>2058 (67.6%)</td>
<td>2773 (67.6%)</td>
<td></td>
</tr>
<tr>
<td>Very Mild NPDR</td>
<td>288 (9.1%)</td>
<td>409 (10.0%)</td>
<td></td>
</tr>
<tr>
<td>Mild NPDR</td>
<td>239 (8.4%)</td>
<td>420 (10.2%)</td>
<td></td>
</tr>
<tr>
<td>Moderate NPDR</td>
<td>147 (5.1%)</td>
<td>282 (6.9%)</td>
<td></td>
</tr>
<tr>
<td>Severe NPDR</td>
<td>24 (0.8%)</td>
<td>48 (1.2%)</td>
<td></td>
</tr>
<tr>
<td>Very Severe NPDR</td>
<td>5 (0.8%)</td>
<td>1 (&lt;0.01%)</td>
<td></td>
</tr>
<tr>
<td>PDR</td>
<td>92 (3.2%)</td>
<td>162 (3.9%)</td>
<td></td>
</tr>
<tr>
<td>PDR with HRC</td>
<td>7 (0.2%)</td>
<td>9 (0.2%)</td>
<td></td>
</tr>
<tr>
<td><strong>DME Present</strong></td>
<td>176 (5.3%)</td>
<td>278 (6.4%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>DR Present</strong></td>
<td>802 (24.6%)</td>
<td>1331 (30.7%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Vision Threatening DR</strong></td>
<td>301 (9.2%)</td>
<td>520 (11.9%)</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Data are N (%); NMFP, nonmydriatic fundus photography; UWFI, ultrawide field imaging; SD, standard deviation; DR, diabetic retinopathy; DME, diabetic macular edema; NPDR, nonproliferative DR; PDR, proliferative DR; Vision Threatening DR is defined as moderate NPDR or worse, PDR or the presence of DME.
### Table 3 - Effect of age on patient ungradable rates for diabetic retinopathy

<table>
<thead>
<tr>
<th>Age Group</th>
<th>NMFP</th>
<th>UWFI</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>DR</td>
<td>DME</td>
<td>N</td>
<td>DR</td>
<td>DME</td>
</tr>
<tr>
<td>Less than 50 years</td>
<td>615</td>
<td>2.6%</td>
<td>2.8%</td>
<td>748</td>
<td>0.9%</td>
<td>1.2%</td>
</tr>
<tr>
<td>50 to 70 years</td>
<td>742</td>
<td>10.5%</td>
<td>8.8%</td>
<td>1028</td>
<td>2.3%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Over 70 years</td>
<td>248</td>
<td>24.6%</td>
<td>22.6%</td>
<td>357</td>
<td>9.0%</td>
<td>12.0%</td>
</tr>
</tbody>
</table>

N, number of patients; NMFP, non-mydriatic fundus photography; UWFI, ultrawide field imaging; DR, diabetic retinopathy; DME, diabetic macular edema.
**Figure 1**: Joslin Vision Network nonmydriatic fundus photography (F1: 30 degree field centered on the optic disc, F2: 30 degree field centered on the macula, NM-1: 45 degree field centered between the optic disc and the macula, NM-2: 45 degree field superotemporal, NM-3: 45 degree field nasal) compared to Joslin Vision Network ultrawide field imaging (White rectangle: approximate area covered by 100 degree ultrawide field image and background image is a 200 degree ultrawide field image). Highlighted areas show selected pathology evident peripheral to the Joslin Vision Network fields. Black arrowheads show selected areas of cotton wool spots. White arrowheads show selected areas of hemorrhages and/or microaneurysms. White asterisks show selected areas of intraretinal microvascular abnormalities.
Figure 1
219x172mm (300 x 300 DPI)