

# Clinical Evaluation of Patients with Diabetic Retinopathy

## *Accuracy of the Inoveon Diabetic Retinopathy-3DT System*

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**Purpose:** This study analyzed the accuracy of the Inoveon Diabetic Retinopathy (DR-3DT) system (Inoveon Corp., Oklahoma City, OK), a scalable evaluation method for the management of diabetic retinopathy using high-quality digital retinal imaging.

**Design:** An independent, masked, cross-sectional, clinical validation study.

**Participants:** Two hundred ninety adult patients with diabetes from the Chickasaw Nation's Carl Albert Indian Health Facility in Ada, Oklahoma.

**Methods:** All participants underwent DRS7 imaging using a Zeiss FF450 fundus camera with images recorded on 35-mm film and a Kodak DCS520 digital camera back. Masked double grading with independent third reader adjudication yielded an Early Treatment Diabetic Retinopathy Study (ETDRS) Final Retinopathy Severity Scale Level (ETDRS Level) and macular edema stage for each eye. The presence of  $\geq$  ETDRS Level 53, questionable or definite clinically significant macular edema in either eye, or ungradeable images was defined as a threshold event requiring referral.

**Main Outcome Measures:** Accuracy (sensitivity, specificity, predictive values) of the digital system relative to the film "gold standard" on the threshold referral criteria per patient.

**Results:** All patients with gradeable 35-mm slides from at least one eye were included in this per patient analysis ( $n = 290$ ). The prevalence of threshold events was 19.3%. The sensitivity of the digital system in detecting threshold events was 98.2% (95% confidence interval [CI], 90.5%–100.0%) and specificity 89.7% (95% CI, 85.1%–93.3%). The positive predictive value was 69.5% and negative predictive value 99.5% for this sample.

**Conclusions:** When compared with the "gold standard," Inoveon's DR-3DT system provides highly accurate diabetic retinopathy referral decisions. Given their inherent advantages, high-quality digital imaging systems could replace the film "gold standard" as the basis for scalable, accessible, diabetic retinopathy evaluation. *Ophthalmology* 2002;109:595–601 © 2002 by the American Academy of Ophthalmology.

Efficacious therapy for diabetic retinopathy has been available for more than two decades.<sup>1–5</sup> Timely laser photoco-

agulation can achieve a 10-fold reduction in blindness from proliferative diabetic retinopathy<sup>6</sup> and a 3-fold reduction in moderate visual loss from diabetic macular edema.<sup>7</sup> National educational campaigns have informed nonophthalmologist physicians, ophthalmologists, optometrists, and the public about the benefit of timely therapy.<sup>8,9</sup> Nonetheless, diabetic retinopathy remains the leading cause of blindness among working-age Americans.<sup>10–14</sup> With an increasing prevalence of type 2 diabetes in the general population, and a significantly disproportionate burden of diabetes among certain minority groups, diabetic retinopathy is a major public health threat.<sup>15</sup> To counter this threat, particularly in light of the striking efficacy of therapy, numerous public and professional organizations have recommended annual dilated retinal evaluation for all patients with diabetes.<sup>6,8,16</sup>

Over the past 20 years, a set of procedures has been developed and refined for taking standardized photographs of specific areas of the retina; systematically evaluating lesions relevant to the natural history of diabetic retinopathy and diabetic macular edema; and combining those lesion scores into ordinal severity scales, the levels of which reflect

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increasing risk of vision loss. This standard protocol uses color, stereo, 30°, 35-mm slides of the Diabetic Retinopathy Study seven standard fields (DRS7) first defined for the Diabetic Retinopathy Study (DRS).<sup>17</sup> Nonphysician experts, under the supervision of retina specialists, use an established classification system to locate and quantify at least 11 lesions or features for diabetic retinopathy and at least three for diabetic macular edema. The data on these lesions provide input for an algorithm that generates diabetic retinopathy severity levels for each eye.

The modified Airlie House Classification (MAHC) of diabetic retinopathy was used for the DRS with an extension of this classification system used for the Early Treatment Diabetic Retinopathy Study (ETDRS).<sup>18</sup> The ETDRS Final Retinopathy Severity Scale<sup>19</sup> was developed from the ETDRS control data to define specific severity levels (ETDRS Levels), indicating increasing risk of neovascularization developing. This severity scale was used for the Diabetes Control and Complications Trial (DCCT).<sup>20</sup> A variant of the MAHC, the Vanderbilt Classification System asks graders to count and measure lesions to score borderline cases on ordinal lesion scales rather than refer to standard photographs. Its internal reliability has been shown to be highly accurate and reproducible in assigning ETDRS Levels.<sup>21</sup> Recently this system was modified by explicit comparison with the MAHC on a standard image set to yield an externally valid, essentially equivalent, variant of the MAHC (unpublished data). In addition to diabetic retinopathy levels, the ETDRS defined a staging system for diabetic macular edema, including a subgroup with "clinically significant macular edema" (CSME) that showed the greatest treatment benefit from macular photocoagulation.<sup>22</sup> This combined protocol, yielding ETDRS Levels and macular edema stages, has been referred to by Singer et al<sup>23</sup> as the "gold standard" and recently reaffirmed by Lee<sup>24</sup> as the "criterion standard" for staging diabetic retinopathy. In its most recent position statement, the American Diabetes Association notes that this protocol is "more sensitive at detecting retinopathy than clinical examination" when skilled photographers and expert readers are used.<sup>25</sup>

This study reports the accuracy of the Diabetic Retinopathy-3DT system from Inoveon Corp. (Oklahoma City, OK), compared with the "gold standard" film protocol. This digital system combines high-quality, stereo, digital, retinal imaging of the DRS7 fields, the public Internet for data transmission, and an established ETDRS reading center. To our knowledge, this is the first digital system to deliver "gold standard" ETDRS protocol diabetic retinopathy evaluation in clinical environments.

## Materials and Methods

Color, stereo, 30°, DRS7 digital images were acquired using a Kodak DCS520 digital camera (Eastman Kodak, Rochester, NY) coupled with a Zeiss FF450 fundus camera (Carl Zeiss Instruments, Jena, Germany). Individual 30° images have a spatial resolution of 1152 × 1152 pixels and pixel depth of 24 bits of color data. Image compression was not used. Patient scheduling, photography, image grading, and reporting are scheduled by the Internet-based client-server DR-3DT architecture that

complies with the latest Health Care Financing Administration guidelines for patient confidentiality, data security, and data integrity.<sup>26</sup>

## Study Design

An independent, masked, cross-sectional, clinical validation of a new method by assessing agreement of the new method with the existing "gold standard" method.

## Subjects

Approval of the University of Oklahoma Health Sciences Center Institutional Review Board was obtained before initiation of the study. Patients with the diagnosis of diabetes mellitus, older than the age of 18 years, were recruited from the primary care clinics of the Chickasaw Nation's Carl Albert Indian Health Facility in Ada, Oklahoma. No attempt was made to select patients based on type or duration of diabetes, severity of retinopathy, confounding retinal conditions, or other criteria. Informed written consent was obtained. During the course of the study, clinical referral recommendations were based exclusively on reading center interpretation of the standard film sets.

## Variables

Agreement between the DR-3DT system and "gold standard" film photography in making dichotomous referral decisions for patients with diabetic retinopathy was the primary outcome variable. Based on the American Academy of Ophthalmology Preferred Practice Pattern for Diabetic Retinopathy,<sup>16</sup> the threshold for referral was met when the presence of any of the following conditions was detected in either eye:

1. ETDRS Level 53 or greater<sup>19</sup>
2. Macular edema stage, as defined by the ETDRS, of questionable or definite CSME<sup>22</sup>
3. Ungradeable digital images

Secondary outcome variables were per eye agreement on specific ETDRS Level and macular edema stage between the digital system and film standard.

## DR-3DT and Film Imaging

Participant's eyes were dilated using 2.5% phenylephrine and 1% tropicamide. Stereo fundus photographs of the DRS7 fields were acquired using 35-mm film<sup>27</sup> and the digital system. An experienced retinal photographer, previously certified for DRS7 photography and experienced in the operation of the DR-3DT system, acquired film and digital images during the same setting. The order of the two imaging sessions was determined randomly at the beginning of each day. After developing and sorting, DRS7 film sets were sent overnight to the Vanderbilt Fundus Photography Reading Center for evaluation in a masked fashion. Film results were reported to the eye care providers of the Carl Albert Indian Health Facility within 2 working days. Digital image sets were stored on digital media and sent to the reading center for evaluation.

## Reading Center Procedures

All photographic evaluation was performed by nonphysician expert graders trained to evaluate diabetic retinopathy from DRS7 images using the variant of the MAHC system in which lesions are counted and measured to score borderline cases on ordinal lesion

scales rather than by reference to standard photographs. Digital image sets were presented to the graders using commercial off-the-shelf monitors set to display DRS7 digital, 30° images at 768 × 768 pixels and 24-bit color. A software zoom magnification tool, used during the evaluation of each image, presented the full spatial resolution of the captured image (1152 × 1152 pixels) within the monitor window. Stereoscopic viewing, at full monitor resolution, was supported using alternating presentation of the individual images of the stereo pair viewed through liquid crystal shutter glasses synchronized with the rate of alternating presentation (120 Hz). Grading software for the digital sets always presented the right eye first. Once finished with that eye, the reader could not go back to the right eye while grading the left eye.

Because of differences in the appearance of digital and film sets, it was not possible to prevent graders from knowing which type of images they were grading. However, it was possible to prevent graders from knowing which patient's images they were evaluating and masking them to any previous grading of that same eye. Reading queues were created so that no grader evaluated both the digital and the film set from the same patient during the same week.

All image sets were double graded, with patient care decisions being made on the results of the first grader's evaluation of the standard film sets to expedite reporting to the patient's care provider. The second grader was masked as to the results of the first grader's evaluation. The double grading procedure used for the DCCT was followed for this study, in which differences between first and second graders' evaluations greater than specified thresholds (usually greater than 1 step per lesion per field) are sent to a senior grader for adjudication.<sup>28</sup>

## Statistical Analysis

The study was planned with a sufficient number of patients to yield expected 95% confidence intervals 10% or less in width around the observed sensitivity and specificity. Because the primary outcome variable, referral or nonreferral of a patient evaluated for diabetic retinopathy, was dichotomous, the primary analysis evaluated sensitivity, specificity, and predictive values for the digital system in which the grading results of the DRS7 film sets served as the "gold standard" for the true disease state.<sup>29</sup> A secondary analysis evaluated the referral criteria on all eyes studied.

Although CSME was only differentiated into three stages (none, questionable, or definite), diabetic retinopathy severity was assigned one of nine ETDRS levels (10,14; 15,20; 35; 43; 47; 53; 61; 65; or 71,81). Agreement between digital and "gold standard" film diabetic retinopathy severity gradings was evaluated with  $\kappa$  and weighted  $\kappa$ . Consistent with the DCCT, a weighting of 1.0 was used for perfect agreement, 0.75 for agreement within one step, 0.5 within two steps, and 0.00 for disagreement greater than two steps.<sup>30</sup> Landis and Koch<sup>31</sup> recommend the following scale for unweighted  $\kappa$  statistics: 0 to 0.20 = slight agreement; 0.21 to 0.40 = fair agreement; 0.41 to 0.60 = moderate agreement; 0.61 to 0.80 = substantial agreement; and >0.80 = almost perfect agreement. The ETDRS adopted this scale for weighted  $\kappa$  statistics as well.<sup>18</sup>

Following the rationale of Bland and Altman,<sup>32</sup> who have detailed methods for comparing a new measurement technique with an established one, an association was sought between digital and film grading differences and the severity of the "gold standard" film grading result. Thus, if the ETDRS levels of an eye were 53 and 61 for digital and film grading, respectively, the difference would be negative one step; if the ETDRS levels were 61 and 47, respectively, the difference would be positive two steps. The means and variance of these differences were compared for

Table 1. Characteristics of Eligible Patients (n = 290)

Characteristic	n	%
Age (yrs)		
<30	6	2.1
30-49	75	25.9
>49	209	72.1
Female gender	162	55.9
Insulin therapy*	92	31.7
Duration of diabetes (yrs) <sup>†</sup>		
<10	193	66.6
10-19	84	29.0
>19	9	3.1

\*Data unavailable for three patients.

<sup>†</sup>Data unavailable for four patients.

each ETDRS level of the film grading. Although the number of steps of difference between the digital and film gradings may not be a completely interval level variable, this intuitive analysis provides a straightforward method of looking for patterns in the differences of the digital and film gradings that would not be evident from calculation of weighted or unweighted  $\kappa$ .

## Results

From August 10 to October 2, 1998, 307 patients were enrolled. Because the "gold standard" is based on DRS7 film sets, patients with ungradeable film sets (n = 17) were excluded, regardless of the quality of their digital sets. However, patients with ungradeable digital sets were included as long as their film sets could be graded. Characteristics of the 290 patients with gradeable film sets are shown in Table 1.

The prevalence of threshold diabetic retinopathy and/or maculopathy was 19.3% (n = 56). The digital system correctly identified 55 of these 56 patients (Table 2). The single error was a result of underreading the patient's macular edema stage from the digital images. Subsequent review of the film set grading showed this patient to have macular edema, but not CSME, as strictly defined by the ETDRS. The sensitivity of the digital system in detecting these referral threshold events was 98.2% (95% CI, 90.5%–100.0%) and specificity 89.7% (95% CI, 85.1%–93.3%). Of the 24 patients who were overreferred from their digital camera images, 16 (67%) were because of ungradeable digital images. The other eight patients' digital images were overread on the macular edema stage. The positive predictive value was 69.5% and negative predictive value was 99.5% for this sample (Table 3). To estimate predictive values based on the prevalence of referable diabetic retinopathy or maculopathy for a general population, results for a hypothetical population of 1000 pa-

Table 2. Referral of Patients (%) Comparing "Gold Standard" Film and Digital Camera Results by Combined Retinopathy Level and Macular Edema Thresholds

		"Gold Standard" Film		
		Yes	No	Total
Digital camera	Yes	55 (98.2)	24 (10.3)	79
	No	1 (1.8)	210 (89.7)	211
	Total	56	234	290

Table 3. Sensitivity, Specificity, and Predictive Values for Referral of Patients

Parameter	Patient Referral Criteria		
	Retinopathy Level or Macular Edema	Retinopathy Level	Macular Edema
Sensitivity	98.2%	92.0%	87.8%
Specificity	89.7%	90.2%	93.8%
Sample prevalence	19.3%	8.6%	16.9%
Predictive value of a positive test	69.5%	47.0%	74.2%
Predictive value of a negative test	99.5%	99.2%	97.4%
Estimated population prevalence*	18.2%	10.9%	8.8%
Predictive value of a positive test	68.0%	53.5%	57.7%
Predictive value of a negative test	99.6%	98.9%	98.8%
Number of patients screened <sup>†</sup>	1000	1000	1000
Predicted number of correct referrals	179	100	77
Predicted number of overreferrals	84	87	57
Predicted number of underreferrals	3	9	11

\*Positive and negative predictive values calculated with sensitivities and specificities for patients in this study and prevalence estimates from the Wisconsin Epidemiologic Study of Diabetic Retinopathy.<sup>39,40</sup>

<sup>†</sup>The bottom portion of the table gives results for a hypothetical population of 1000 patients, assuming the estimated population prevalence from the Wisconsin Epidemiologic Study of Diabetic Retinopathy.

tients with diabetes, assuming the estimated population prevalence from the Wisconsin Epidemiologic Study of Diabetic Retinopathy, are shown in Table 3.

As expected, the sensitivity of the digital system decreased and the specificity increased if the retinopathy level or macular edema thresholds were analyzed independently (Table 4), or a per eye rather than per patient analysis was performed (Table 5). Twenty-nine of the 34 eyes (85.3%) with ≥ ETDRS level 53 as a result of “gold standard” film grading reached or exceeded this threshold by grading of the digital images. Fifty-two of the 65 eyes (80.0%) exceeding the macular edema threshold as a result of “gold standard” film grading exceeded this threshold by grading of the digital images.

Secondary per eye analysis of ETDRS level agreement (Table 6) showed perfect agreement on 80.1% of eyes and agreement to within one step of the film “gold standard” on 89.6%. Digital images from 36 eyes (6.6%) were ungradeable and would have resulted in referral to an ophthalmologist. The proportion of ungradeable digital image sets increased with ETDRS level (P = 0.008, exact chi-square test), supporting referral for patients with ungradeable digital images. Only 11 of 549 eyes (2.0%) and 1 of 549 eyes (0.2%) had digital images misgraded by more than one step and more than two steps, respectively.

Table 7 presents an analysis of the number of steps of difference between digital and film gradings by “gold standard” film ETDRS level. Levene’s test was used to compare variances in the number of steps of difference between digital and film gradings across the full range of film ETDRS levels. Although highly

significant differences (P < 0.001) were apparent, this was in large part due to the small variability at the lowest film ETDRS level (10, 14) which also had the largest sample size. A statistically significant linear trend in the means of the number of steps of difference between digital and film gradings of ETDRS level from lowest to highest film ETDRS level was also apparent. However, this was due to the zero mean at the lowest film ETDRS level (10, 14) where mistakes can only be in the positive direction (it is impossible for digital gradings to be less than film gradings at the 10,14 level). If the 10,14 level is excluded, the linear trend in means disappears (P = 0.30). Two of the nine means were zero, whereas seven were slightly negative, indicating a tendency for the digital grades to underestimate the film grades by a small fraction of a step on average. At ETDRS level 43, the digital gradings averaged 0.2 step less than the film gradings, which was statistically significant (P = 0.02). The 95% CI on the difference ranged from -0.4 of a step to approximately zero steps. The 95% CIs around the remaining means at each film ETDRS level include zero, indicating no significant difference between the average digital and film gradings. When all film ETDRS levels (n = 549) are combined, the difference between digital and film gradings is statistically significant (P = 0.01); however, the 95% CI suggests the true average difference is less than or equal to 0.1 step, a difference that is not clinically meaningful.  $\kappa$  analysis of ETDRS level agreement showed substantial agreement ( $\kappa = 0.71$ , weighted  $\kappa = 0.76$ ) when all images are included (Table 6). After excluding ungradeable images from the analysis,  $\kappa$  increases to 0.78 and weighted  $\kappa$  to 0.89.

Table 4. Referral of Patients (%) Comparing “Gold Standard” Film and Digital Camera Results Separately by Retinopathy Level or Macular Edema Thresholds

		“Gold Standard” Film					
		Retinopathy Level			Macular Edema		
		Yes	No	Total	Yes	No	Total
Digital camera	Yes	23 (92.0)	26 ( 9.8)	49	43 (87.8)	15 ( 6.2)	58
	No	2 ( 8.0)	239 (90.2)	241	6 (12.2)	226 (93.8)	232
	Total	25	265	290	49	241	290

Table 5. Number (%) of Eyes Meeting Specified Threshold Comparing “Gold Standard” Film and Digital Camera Results by Combined and Separate Retinopathy Level and Macular Edema Thresholds

		“Gold Standard” Film								
		Retinopathy Level or Macular Edema			Retinopathy Level			Macular Edema		
		Yes	No	Total	Yes	No	Total	Yes	No	Total
Digital camera	Yes	73 (93.6)	38 ( 8.1)	111	29 (85.3)	34 ( 6.6)	63	52 (80.0)	26 ( 5.4)	78
	No	5 ( 6.4)	433 (91.9)	438	5 (14.7)	481 (93.4)	486	13 (20.0)	458 (94.6)	471
	Total	78	471	549	34	515	549	65	484	549

**Discussion**

Nonphysician expert evaluation of color, stereo, 30°, 35-mm slides of the Diabetic Retinopathy Study seven standard fields (DRS7), with assignment of an ETDRS Final Retinopathy Severity Scale Level (ETDRS Level), and ETDRS macular edema stage is the “gold standard” for the evaluation of diabetic retinopathy.<sup>23,33,34</sup> Compared with this standard, the Inoveon DR-3DT system demonstrated a sensitivity of 98.2%, specificity of 89.7%, positive predictive value of 69.5%, and negative predictive value of 99.5% in identifying those patients in need of referral. Analysis of ETDRS Level agreement showed perfect agreement in 80.1% of all eyes graded. The accuracy of ETDRS Level assignment by digital image grading did not seem to vary to a clinically meaningful extent across the entire range of “gold standard” film ETDRS Levels.  $\kappa$  analysis confirmed “substantial” agreement with this film “gold standard.”

Generally, the agreement between ophthalmoscopy and photographic approaches for diabetic retinopathy evaluation is moderate with poorer sensitivity of ophthalmoscopy, relative to photography, particularly when detecting the early stages of diabetic retinopathy.<sup>33,35,36</sup> Limitations of these studies include the absence of slit-lamp biomicroscopy, which may have unfairly penalized the ophthalmoscopists, and the use of nonstandard photographic approaches, which prevent a true comparison with the DRS7 “gold standard.”<sup>33,35-37</sup> A few small studies have reported direct com-

parisons of ophthalmoscopy by retinal specialists, including slit-lamp biomicroscopy, with DRS7 photography. Even under these optimized conditions, retinal specialists missed a substantial number of cases of diabetic retinopathy, from mild to severe, when compared with DRS7 photography (Valez R, Haffner S, Stern MP, Van Heuven WAJ. Ophthalmologist versus retinal photographs in screening for diabetic retinopathy [Abstract]. Clin Res 1987;35:363A).<sup>34</sup>

When comparing DRS7 photography with contact lens biomicroscopy for the staging of macular edema, the ETDRS found substantial agreement ( $\kappa = 0.65$ ) for appreciable hard exudates within 1 disc diameter of the center of the macula and moderate agreement ( $\kappa = 0.55$ ) for definite retinal thickening within 1 disc diameter of the center of the macula. Substantial agreement ( $\kappa = 0.61$ ) was also found for the presence of CSME. Contact lens biomicroscopy, performed by retinal specialists, undercalled CSME in 117 of 650 eyes in which it was present by DRS7 photography. Photographic graders underread CSME in 168 of 701 eyes in which it was present by contact lens biomicroscopy. Noting the close agreement between these methods, the ETDRS investigators concluded that either method is reliable for the assignment of macular edema stage.<sup>38</sup>

By integrating high-quality digital retinal imaging, “gold standard” methods of image grading, and public Internet data transmission, the Inoveon Diabetic Retinopathy-3DT system accurately evaluates patients in a primary care setting, reliably identifies those patients in need of referral,

Table 6. Number (%) of Eyes by “Gold Standard” Film and Digital Camera Grading\*

		“Gold Standard” Film Retinopathy Level									
		10,14	15,20	35	43	47	53	61	65	71,81	Total
Digital camera retinopathy level	10,14	264 (95.0)	18 (34.0)	4 ( 3.1)							286 (52.1)
	15,20	3 ( 1.1)	22 (41.5)	4 ( 3.1)							29 ( 5.3)
	35	1 ( 0.4)	10 (18.9)	99 (76.7)	8 (25.0)	1 ( 4.3)					119 (21.7)
	43			6 ( 4.7)	21 (65.6)	5 (21.7)		1 ( 6.3)			33 ( 6.0)
	47			1 ( 0.8)	1 ( 3.1)	13 (56.5)	2 (28.6)	2 (12.5)			19 ( 3.5)
	53					2 ( 8.7)	5 (71.4)				7 ( 1.3)
	61							7 (43.8)	1 (12.5)		8 ( 1.5)
	65							1 ( 6.3)	7 (87.5)	1 (33.3)	9 ( 1.6)
	71,81							1 ( 6.3)		2 (66.7)	3 ( 0.5)
	Ungradeable	10 ( 3.6)	3 (5.7)	15 (11.6)	2 (6.3)	2 (8.7)		4 (25.0)			36 ( 6.6)
	Total	278 (50.6)	53 (9.7)	129 (23.5)	32 (5.8)	23 (4.2)	7 (1.3)	16 ( 2.9)	8 ( 1.5)	3 ( 0.5)	549

\*Dark gray cells indicate perfect agreement; light gray cells indicate agreement within one step.

Table 7. Mean and Standard Deviation of Number of Steps Difference between Digital and "Gold Standard" Film Early Treatment of Diabetic Retinopathy Study Level

"Gold Standard" Film Early Treatment of Diabetic Retinopathy Study Level	Number of Gradable Eyes	Mean Number of Steps of Difference	Standard Deviation	95% Confidence Interval around Mean Number of Steps of Difference		P Value of Difference from Zero
10,14	268	0.0	0.2	0.0	0.0	0.06
15,20	50	-0.2	0.7	-0.4	0.0	0.13
35	114	0.0	0.5	-0.1	0.1	0.47
43	30	-0.2	0.5	-0.4	0.0	0.02
47	21	-0.2	0.7	-0.6	0.1	0.13
53	7	-0.3	0.5	-0.7	0.2	0.17
61	12	-0.3	1.4	-1.2	0.5	0.42
65	8	-0.1	0.4	-0.4	0.2	0.35
71,81	3	-0.3	0.6	-1.8	1.1	0.42
All ETDRS Levels	513	-0.1	0.5	-0.1	0.0	0.01

reports an ETDRS level and macular edema stage for each eye, and provides a recommendation for further care from the American Academy of Ophthalmology Preferred Practice Pattern for Diabetic Retinopathy.<sup>16</sup> The ability to deliver accurate diabetic retinopathy evaluations in the environment in which most patients obtain routine diabetes care may provide the foundation for more effective systems to reduce vision loss from diabetic retinopathy. Cost-effectiveness issues will be the focus of future health services research.

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## Appendix

The Inoveon Health Research Group: William Abrams, Robert Adams, Hank Aguado, Cecile C. Armbruster, Theodore E. Brown, Theresa L. Burdge, Judith D. Debelak, F. Scott Gaston, Regina Hansen, Gene S. Hopper, Annie Moreau, OD, Candace Shaw, Sharon Snow, Robert W. Thoma, III, Sudie Walker.

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