Validation of the Electronic Mailing of Retinographs of Diabetic Patients in Order to Detect Retinopathy in Primary Care

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Objective. Evaluate concordance in biomicroscopic evaluation of diabetic retinopathy degree among ophthalmologists. Validation of e-mail transmission of digital fundus photographs of type 2 diabetes patients as a method of diabetic retinopathy detection.

Design. Descriptive study.

Setting. Urban, primary health center, and hospital.

Participants. Type 2 diabetic patients selected of consecutive form when going to the primary health center (n = 352).

Main measurements. Parallel observer-blinded evaluation of degree of retinopathy through biomicroscopy performed by ophthalmologists, against digital photographic images sent by e-mail taken by the family doctors. Concordance in the biomicroscopy among ophthalmologists was previously tested.

Results. Retinopathy was revealed in 25.70% of the retinographs; 10.44% was mild, 12.05% moderate, and 3.21% severe. Weighted kappa was 0.878 for biomicroscopy concordance. Sensitivity in detecting retinopathy is 76.6% and specificity 95.2%; 92.7% and 99.5% for ophthalmologist-derivable retinopathy. Concordance in evaluation of retinopathy degree through biomicroscopy of type 2 diabetes patients as a method of diabetic retinopathy type 2, for detect retinopathy diabética.

Conclusions. Concordance in evaluation of retinopathy degree through biomicroscopy was “very good.” This allows using a single ophthalmologist’s exploration as a reference model. E-mail transmission of the photograph of the back of the eye in type 2 diabetic patients as a retinopathy detection method is feasible. Regardless of the type of retinograph used, the photographs should be taken on the dilated eye, as this significantly improves sensitivity.

Introduction

Diabetic retinopathy (DR) is a highly prevalent, chronic and progressive disease. It is the second cause of blindness in Spain and the second in people of working age. Even in its most aggressive forms, loss of acute vision symptoms are not normally present, so when there is a decrease it is usually too late for effective treatment. For this reason early detection is vital. Laser photocoagulation prevents or delays vision loss in a good number of patients. Photographs of the back of the eye are more reliable than ophthalmoscope for diagnosis. Studies have validated the digital image as the most ideal method for DR screening.

In the Andalusian Health System the diagnosis and follow-up of type 2 diabetic patients is carried out in primary care centres. In those centres, the health network allows digital images taken, to be sent by e-mail to a reference centre to be stored and studied by ophthalmologists for classification and treatment of DR. Studies are required to assess the real use of this method and, its practicality in providing full cover for the diabetic population, and its direct relationship at the 2 care levels and, its potential to reduce costs with a greater benefit for patients and the system.

To achieve this, we proposed the following objectives: to evaluate the concordance of biomicroscopy between ophthalmologists. To analyse the validity of digital photographs (received by e-mail) read by ophthalmologists and family doctors to detect DR, and to look at the benefits for patients.

Methods

Design
Observational, descriptive. Parallel blind assessment, of the degree of DR measured with a biomicroscope and comparing this with a digital photographic image.

Population and Sample
Type 2 diabetic patients, who had not received photocoagulation, consecutively selected on arriving at a clinic.

The sample size for the kappa index is N=196 (15% disagreement ratio, precision 5%, and a 95% confidence level). For validation, a sample size of Na=91, according to Na=N [1/(1–R)], for a 95% negative predictive value, precision 5% and a 95% confidence level, N=73.

Data Collection and Variable Measurement Techniques

Of the remaining 346 retinal photographs 90 With Ocular Retinograph and 247 With Non-Mydriatic (112 Always With No Dilation and 135 With Elective Dilation).

In Hospital, 328 Biomicroscopies Were Performed on the Same Eye (12 Patients [24 eyes] Did Not Turn Up).

General Scheme of the Study
Observational, descriptive. Parallel, blind assessment, for observers of the degree of diabetic retinopathy by means of a study with a biomicroscope and by comparing this with a digital photographic image (retinography).

Data Analysis

Weighted linear and quadratic kappa index, was used to assess the agreement of the biomicroscopy between ophthalmologists. For the strength of the agreement the Landis and Koch scale was used. To test the validity, sensitivity (Se), specificity (Sp), the po-
The agreement in biomicroscopy was “very good.” It enables the examination by an ophthalmologist to be like a reference test. The time between the 2 tests was not seen to influence the differences, since it was too short for the lesions to progress. We found the sensitivity to be slightly less than the 80% recommended by the British Diabetic Association15 and a specificity slightly higher than the recommended 95%. With NOMYD-SD, the sensitivity is clearly lower, although specificity is maintained. This decrease in sensitivity is found by the majority of authors. When the eyes which had bad quality photographs were subsequently diluted, we found a great improvement in the sensitivity, although lower than MYD dilating to 100% and with higher temporal field. In this case, the sensitivity and specificity are similar to those of Baeza Díaz et al,11 using 3 fields and dilation if the examination quality was poor, or Murtatroyd et al,12 who used 3 fields with dilation, and somewhat higher than that of other authors such as Harding et al13 and Lawrence,14 with 3 fields, or Scanlon et al,15 Olson et al,12 and Stellingwerf et al,14 with 2.

The negative predictive value was taken as a reference for the sample size, since, on having an effective treatment for DR, it is important to avoid the patients with a lesion being diagnosed as healthy. In our case it was very good and similar to that found by Stellingwerf et al13 and lower than that of Baeza Díaz et al.11

### Table 1

Analysis of the Digital Photography Assessments Made by Ophthalmologists and Family Doctors as a Method of Detecting Retinopathy in General and Referable in Particular (Degree Equal to or Greater Than Moderate)

<table>
<thead>
<tr>
<th>Ophthalmologist</th>
<th>Family Doctor</th>
<th>Ophthalmologist</th>
<th>Family Doctor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>74.6% (64.3-83.8)</td>
<td>76.3% (63.6-83.1)</td>
<td>80.7% (70.9-88.6)</td>
</tr>
<tr>
<td>Specificity</td>
<td>95.5% (90.7-99.9)</td>
<td>89.3% (72.8-94.8)</td>
<td>81.5% (58.6-98.1)</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>86.6% (74.9-95.7)</td>
<td>56.9% (36.7-72.5)</td>
<td>51.4% (40.4-62.3)</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>91.3% (84.7-95.6)</td>
<td>91.01% (85.5-94.6)</td>
<td>96.4% (86.7-99.6)</td>
</tr>
</tbody>
</table>

### Table 2

Analysis of the Validity of Digital Photography Read by Ophthalmologists by Retinograph Type (Mydriatic, Non-Mydriatic With Elective Dilation and Non-Mydriatic With No Dilation)

<table>
<thead>
<tr>
<th>Hydric</th>
<th>Non-Hydric Without Elective Dilation</th>
<th>Non-Hydric With No Dilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>65% (62.1-68.1)</td>
<td>76.5% (66-85)</td>
</tr>
<tr>
<td>Specificity</td>
<td>96.4% (85.7-99.2)</td>
<td>95.4% (84.7-99.2)</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>86.5% (82.9-89.1)</td>
<td>93.3% (82.6-95.3)</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>91.4% (89.7-93.1)</td>
<td>97.3% (95.4-98.6)</td>
</tr>
</tbody>
</table>

### Results

There were 352 retinal photographs performed; 99 with a mydriatic retinograph (MYD), 247 non-mydriatic (NONYD): 112 always with no dilation (NOMYD-ND) and 135 with elective dilation (NOMYD-D). Six eyes (1.7%) were lost due to storage errors and 2 due to duplication of the examination in the same eye. There were no losses in the electronic transmission. The mean age and standard deviation of the patients was 65.4±9.9 years.

The ophthalmologist considered 28% of the examinations non-assessable (17.2% of those performed with MYD, 38.4% of the NOMYD-ND, and 27.4% of the NOMYD-D) (P=0.0027). Cataracts were more common in the non-assessables (63.42%) than in the assessables (15.32%) (P=0.001). Similarly with other problems of transparency (5.8% compared to 4.9%, P=0.005). A family doctor made 291 examinations, of which 23.71% were non-assessable compared with 50.9% which made 55 (P=0.004).

The agreement in biomicroscopy ranged between 2 and 68 days. The mean time between the retinograph and the biomicroscopy was 15.6 days, and 1.8%, SDR; and 0.3% very severe (VSDR). The family doctor considered 13.6% of the retinal photographs non-assessable. Of the assessable ones, 36.5% had a lesion: 12.65% with no diagnosis. Of the 28.7% who had a lesion: 12.65% in the retinograph and in the 1 lesion was MoDR. Four were non-assessable (1 due to a detached retina, 2 due to cataracts, and 1 with no diagnosis). Of the 28.7% who had a lesion: 12.65% were MiDR; 13.9%, MoDR; 3.2% severe (SDR).

In the patients who had had poor quality photographs were subsequently diluted, we found a great improvement in the sensitivity, although lower than MYD dilating to 100% and with higher temporal field. In this case, the sensitivity and specificity are similar to those of Baeza Díaz et al,11 using 3 fields and dilation if the examination quality was poor, or Murtatroyd et al,12 who used 3 fields with dilation, and somewhat higher than that of other authors such as Harding et al13 and Lawrence,14 with 3 fields, or Scanlon et al,15 Olson et al,12 and Stellingwerf et al,14 with 2. The negative predictive value was taken as a reference for the sample size, since, on having an effective treatment for DR, it is important to avoid the patients with a lesion being diagnosed as healthy. In our case it was very good and similar to that found by Stellingwerf et al13 and lower than that of Baeza Díaz et al.11
Although 28% of the examinations were non-assessable, it would be 5.8% if we discard those who had cataracts or opacities, which is around the 5% recommended by the British Diabetic Association.\textsuperscript{10} If we analyse by methods, the losses decrease with dilation, and this difference is statistically significant. Murgatroyd et al.\textsuperscript{12} achieved a reduction in non-assessables from 26% to 5% by dilating the eyes to 100%. The difference found between the MYD and NOMYD could be due to 3 different causes: the first could be the dilation of the eyes to 100% instead of 50.74% and, also, a higher dilation by using 2 drops of tropicamide and phenylephrine if 1 was not sufficient. The second could be the greater temporal field which cannot be done with NOMYD. This would have less influence because, although some authors, such as Baeza et al.\textsuperscript{1,11} found slight improvements in the sensitivity for retinopathy, others, such as Perier et al.\textsuperscript{13} and Baeza et al.\textsuperscript{11} themselves, did not find any when they studied referable retinopathy. Also, the third field does not reduce the losses. The third reason could be the difference in technical quality of the retinal photographs. That from the MYD was higher than the NOMYD used, which was a portable apparatus with poor software.

On the other hand, many disadvantages were observed: MYD required much more time to learn than NOMYD and it resulted in one of the 3 doctors refusing to use it; the time required, 12 examinations were made with NOMYD for every 5 with MYD, with the need for more health staff, and lastly, the inconvenience for the patients, longer waiting time in clinic and then a much longer and uncomfortable pupil dilation.

The reading of the digital photograph by a family doctor is very safe when detecting a significant DR. Good sensitivity was found, 95.2%, and a very good NPV of 99% when MoDR or higher was assessed, which ensures that patients with DR are not diagnosed as healthy. However, the specificity of 81.5% and a PPV of 47.6% to detect MoDR or higher, raises doubts on if the high number of false positives in a disease like DR, which could mean telling patients that they do not have it, counteracts the benefits that practically no lesion escaped. In any case, it is clear that training in reading, the only objective difference between these and the ophthalmologist, is essential.

As regards benefits to the patients (and for the health system), half of them would have avoided going to the ophthalmologist and almost all of them that had to go had a DR (16.8% MoDR) or opacities.

To send the digital photograph of the back of the eye of type 2 diabetics by e-mail, as a method of detecting and monitoring DR, is viable and on setting it up the following recommendations should be taken into account:

- The retinal photograph should be the non-mydriatic type, since the management of mydriasis is too complex and slow.
- The retinal photograph should be taken by photographing at least 2 retinal fields of 45° (a single field has been rejected by several authors due to its insufficient validity\textsuperscript{11,12,13,15,16,20,21} and dilating with tropicamide, as it significantly improves sensitivity and the percentage of assessable photographs.
- If the family doctor is going to read the photographs in the health centre, training must be improved to avoid the high number of false positives found.
- The person who performs the retinal photographs should do the highest number possible, since the percentage of non-assessables significantly decreases with practice.

With these recommendations, it would mean that only between 30% and 40% of patients would have to be seen by the ophthalmologist in the first visit, and given the high percentage of opacities in the non-assessables, it is likely that in the following reviews the percentage of referrals would be even less on this problem being controlled.


