Original article

Ophdiat®: Five-year experience of a telemedical screening programme for diabetic retinopathy in Paris and the surrounding area

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Abstract

Aim. – This report describes our 5 years of experience with the ophthalmological diabetes telemedical network Ophdiat®, designed to screen for diabetic retinopathy.

Methods. – Seventeen hospitals, 11 primary healthcare centres and two prisons in the Paris area were gradually equipped with a non-mydriatic funduscopic camera between June 2004 and December 2009. Photos were taken by trained orthoptists and nurses, and interpreted by an average of seven certified ophthalmologists. The software was updated twice in 2008.

Results. – In all, 38,596 patients were screened during 51,741 examinations between June 2004 and December 2009. Of these patients, 13,726 (26.55%) were referred to an ophthalmologist because of unreadable photographs (9.94%), advanced stages of retinopathy (14.71%) or concomitant eye diseases (1.90%). Patients screened in hospitals and prisons exhibited a greater prevalence of retinopathy and at more advanced stages.

Conclusion. – Telemedicine is a screening method that is well adapted for diabetic patients. In view of the increasing number of such patients and the decreasing number of ophthalmologists, expansion of the Ophdiat® screening network is desirable.

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Keywords: Diabetes; Diabetic Retinopathy; Ophdiat®; Screening; Non-mydriatic funduscopic camera; Telemedicine

1. Introduction

Screening for diabetic retinopathy helps towards the early diagnosis of advanced stages of the disease, which is of crucial importance for choosing the appropriate treatment and preventing further visual loss [1,2]. According to both interna-
tional recommendations and those of the French National Health Authority, the Haute Autorité de Santé (HAS), an annual examination of the ocular fundus should be done in diabetic patients who have either no documented or mild retinopathy [1,3–6]. Screening for retinopathy should be done by retinography, as it is a more sensitive technique than indirect ophthalmoscopy [7–9]. Although retinal photographs may be taken by doctors and paramedical personnel outside of ophthalmological centres, the photos have to be interpreted by a retinal specialist [10]. The characteristics of diabetic retinopathy, combined with the progress made in data-transfer systems, constitute an optimal basis for telemedicine [11]. Telemedical networks that screen for diabetic retinopathy are, in fact, already working in several countries, and good results have been reported [12–18]. However, demographic studies have found that only 40 to 60% of the diabetic population undergoes regular ocular screening [19,20].

The present report describes our 5-year experience of the Ophthalmology Diabetes Telemedicine Network (Ophdiat®), which covers Paris and the surrounding area known as the Île-de-France.

2. Methods

The Ophdiat® network was created in 2004 with the aim of improving the ophthalmological screening of diabetic patients in the Île-de-France area. The screening centres that make up this network are linked via a central server to an ophthalmological reading centre. The organization and details of the network have been described elsewhere [21] and, hence, are only briefly covered here.

From 24 June 2004 to 31 December 2009, an ever-increasing number of hospitals and primary healthcare centres (Fig. 1 and Table S1; see supplementary material associated with this article online) were equipped with 45° non-mydratic fundusscopic cameras (either the Canon CR-DGi, Tokyo, Japan, or Topcon’s TRC-NW6, Rotterdam, The Netherlands), and their orthoptists and nurses trained to take retinal photographs. By the end of 2009, 30 active centres were taking part in the screening programme, including 17 diabetic or internal medicine wards of hospitals, 11 primary healthcare centres and two medical departments located in prisons. The number of ophthalmologists certified for photograph interpretation by the Ophdiat Reading Centre increased from three in 2004 to 14 in 2009, but an average of only seven ophthalmologists a year were actively collaborating in the Ophdiat® network itself. The network is coordinated by a committee comprising a director (P.M.), administrative coordinator (A.C.), coordinator of the Reading Centre (A.E.) and a full-time orthoptist (N.R.), who is in charge of the technical training and responsible for ensuring the quality of follow-up. This Coordinating Committee is responsible for organizing, expanding and evaluating the results obtained by the network, monitoring the efficacy of the screening programme, communication, fund-raising, camera evaluation and software upgrades.

Ophdiat® is supported by the Assistance Publique des Hôpitaux de Paris (Public Assistance for the Hospitals of Paris; an organization covering Paris’ public-sector hospitals), the Regional Health Agency for the Île-de-France, the Organisme pour la Prévention de la Cécité (Organization for the Prevention of Blindness) and the Valentin Haüy Association.

The screening procedure conforms to the recommendations of a group of experts for the screening of diabetic retinopathy by retinal photographs, as well as the recommendations of the French medical associations ALFEDIAM (French-Speaking Association for the Study of Diabetes and Metabolic Diseases) and National Agency for Accreditation and Evaluation in Healthcare (ANAES) [5,6,22]. Patients eligible for screening had either mild diabetic retinopathy (DR) or no documented DR. Most patients were screened during consultations/hospitalizations at their corresponding institutions.

Good patient compliance and clear optical media were crucial for obtaining good-quality photos. If necessary, pupils were dilated with one drop of 0.5% tropicamide after medical consultation. Two pictures were taken, one centred on the posterior pole and the other on the optic disc. Photos were compressed in the JPEG format and sent via the Internet, together with the relevant clinical information, to the central medical server for interpretation and storage. Pictures were graded according to the following stages of DR: none; mild; moderate; severe non-proliferative (NPDR); moderate proliferative (PDR); and proliferative with a high risk of blindness [23–26]. Macular oedema was defined as the presence of hard exudates at the posterior pole. Patients with moderate NPDR or more advanced stages of retinopathy, macular oedema, concomitant eye diseases or insufficiently clear photos were referred to an ophthalmologist within a specified period of time. All other patients were asked to have new retinal photographs taken 1 year later. A report of the screening examination was sent to both the patients and their general practitioners (GPs).

Features designed to ensure the efficacy and safety of the programme have been described elsewhere [27]. Software was updated twice in 2008 to improve its efficacy and safety. In January 2008, a new function was added to the software to facilitate double readings of the photographs and enhance the accuracy of their interpretation. Every month, 5% of the previous month’s patients (a percentage chosen by the administrator) are selected and automatically merged with the new patients. The software compares the diagnoses reached in each of the two readings and displays the results of discordant gradings, which are then reevaluated by the senior ophthalmologist. If the first grading is correct, the report stands, but if the second is correct, the software automatically replaces the initial report and notifies the screening centre to this effect. The traceability of all these procedures is preserved in the database. The percentage of discordant results in the double readings is calculated automatically, and the following features have also been automated: the time lag between acquisition of images and their interpretation; the percentage of non-interpretable pictures; and the number of screening examinations conducted at each centre. In addition, patients are classified according to the number of examinations they have undergone, and those who fail to attend their recommended follow-up examination are automatically listed. Those
responsible for grading the images are required to change their passwords every 3 months.

In the present study, the patients’ data and results of the screening examinations were retrospectively collected from 24 June 2004 to 31 December 2009 by means of the telemedical network described above. Data were analyzed using Excel 2007 software. For the statistical analyses, the percentages of non-gradable photographs were compared by the Mann–Whitney test.

3. Results

By 31 December 2009, 51,741 screening examinations had been completed for 38,596 patients in the Île-de-France area.
During the 5.5 years of the study period beginning in June 2004, the number of screening examinations and new patients increased constantly (Fig. 2).

Around 73% of all patients were diagnosed as having mild DR or none at all, and annual screening by a funduscopic camera was recommended. However, not all of these patients came to be screened the year after their initial examination, although the annual attendance tended to increase, with 38.71% attending in 2004, 37.07% in 2005, 41.34% in 2006, 53.36% in 2007 and 51.86% in 2008. It was not possible to ascertain whether the non-attending patients had undergone ophthalmological examination elsewhere in the year.

Most patients ($n = 29,811; 77.23\%$) were screened only once, but around 15% came twice, around 5% came three times, and around 3% attended between four and 14 times. These data also included the patients screened for the first time in 2008.

In our present study, 13,726 of the 51,741 screening examinations (26.55\%) resulted in referral to an ophthalmologist because of advanced (anything more than mild) DR (14.71\%), suspected glaucoma or other eye disease (1.90\%), or non-gradable pictures (9.94\%). In 199 cases (0.38\%), the patients were already known to have more than mild DR before being screened, so no retinal photographs were indicated.

Overall, 9.94% of the photographs were not gradable, but the annual rates of such photographs decreased from 12.00\% in 2004 down to 10.00\% in 2005, 9.70\% in 2006, 8.20\%, 8.60\% in 2008 and 8.25\% in 2009. The main reasons for insufficiently clear pictures were small pupils, cataract or poor patient compliance. The mean age of patients with non-gradable photos was 64.81 $\pm$ 13.65 years, which was significantly older than the mean age of patients with gradable pictures (54.21 $\pm$ 20.13 years; $P < 0.0001$). Of all the pictures, 93.90\% were interpreted on the day they were taken, while the remaining 6.10\% were read 2 days later. The mean number of photographs read by each ophthalmologist increased constantly from 2004 to 2008 (Fig. 3).

The results after double readings were concordant for a mean 96.85\% of the pictures (range: 92–100\%).

Our study patients’ characteristics and the results of the screening examinations are presented in Table 1 for the total number of patients and examinations, as well as according to the number of patients examined in hospitals, primary healthcare settings and prisons.

4. Discussion

Telemedicine is considered an optimal means of screening for DR [11]. The Ophdiat® network was designed to cover Paris and the entire surrounding Île-de-France area, which together comprise nearly 12 million inhabitants (11,659,260). According to a representative national sample of diabetic patients for the period 2007–2010, the prevalence of diabetes in this population was 3 to 6\% and expected to increase [20]. However, the number of ophthalmologists [$n = 1358$, including 568 who are intra muros (private), according to France’s National Council of the Order of Physicians] is far too small to be able to screen all these patients. Nevertheless, more than 50,000 screening examinations were completed over 5.5 years by the Ophdiat® network, the scope and numbers of which are constantly increasing.

To our knowledge, the screening results for so many patients over such a long period of time have never before been reported by any previous study. The total prevalence of DR found for Paris and its surrounding area (24.28\%) during this time was in agreement with the expected prevalence, which was between 21\% and 27.8\% [28,29].

Both patients and ophthalmologists benefited from the telemedical network. The patients saved time, as the photographs were often taken during their general or endocrinological consultations. Furthermore, screening was often done without pupil dilation, so patients were not hampered by blurred vision after the examination. Ophthamologists benefited because the pictures were taken by trained personnel, thus improving the quality of the photographs, and interpreted by retinal specialists certified to grade DR [10]. For each patient, two pictures were...
Diabetic retinopathy (DR) screening results for all patients/examinations and according to screening site.


<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Hospitals</th>
<th>Primary healthcare centres</th>
<th>Prisons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n = 17)</td>
<td>(n = 13)</td>
<td>(n = 2)</td>
<td></td>
</tr>
<tr>
<td>Total number of patients</td>
<td>38596</td>
<td>34992</td>
<td>3388</td>
<td>216</td>
</tr>
<tr>
<td>Gender (female/male, %)</td>
<td>44.40/55.60</td>
<td>44.66/55.34</td>
<td>44.83/55.17</td>
<td>1.85/98.15</td>
</tr>
<tr>
<td>Age (years, mean ± SD)</td>
<td>56.00 ± 21.00</td>
<td>55.58 ± 21.22</td>
<td>60.91 ± 11.80</td>
<td>53.12 ± 12.32</td>
</tr>
<tr>
<td>Type 1 diabetes</td>
<td>19.04% (7350)</td>
<td>20.33% (7114)</td>
<td>5.70% (193)</td>
<td>19.91% (43)</td>
</tr>
<tr>
<td>Type 2 diabetes, ID</td>
<td>26.13% (10,084)</td>
<td>27.93% (9774)</td>
<td>8.44% (286)</td>
<td>11.11% (24)</td>
</tr>
<tr>
<td>Type 2 diabetes, NID</td>
<td>50.22% (19,383)</td>
<td>46.89% (16,407)</td>
<td>83.80% (2839)</td>
<td>62.43% (137)</td>
</tr>
<tr>
<td>Other</td>
<td>4.61% (1779)</td>
<td>4.85% (1697)</td>
<td>2.06% (70)</td>
<td>5.55% (12)</td>
</tr>
<tr>
<td>Duration of diabetes (mean ± SD, years)</td>
<td>12.72 ± 40.18</td>
<td>12.87 ± 39.38</td>
<td>11.34 ± 48.68</td>
<td>10.06 ± 7.12</td>
</tr>
<tr>
<td>Total number of diagnosesa</td>
<td>51741 (100%)</td>
<td>47553 (91.91%)</td>
<td>3922 (7.58%)</td>
<td>266 (0.51%)</td>
</tr>
<tr>
<td>Absence of DR</td>
<td>75.72% (36,281)</td>
<td>75.20% (33,335)</td>
<td>82.74% (2785)</td>
<td>74.88% (161)</td>
</tr>
<tr>
<td>Prevalence of DR (%)</td>
<td>24.28% (11,631)</td>
<td>24.80% (10,996)</td>
<td>17.26% (581)</td>
<td>25.12% (54)</td>
</tr>
<tr>
<td>Mild NPDR</td>
<td>12.45% (5967)</td>
<td>12.73% (5643)</td>
<td>9.09% (306)</td>
<td>8.37% (18)</td>
</tr>
<tr>
<td>Moderate NPDR</td>
<td>9.11% (4366)</td>
<td>9.31% (4129)</td>
<td>6.30% (212)</td>
<td>11.63% (25)</td>
</tr>
<tr>
<td>Severe NPDR</td>
<td>2.34% (1122)</td>
<td>2.38% (1055)</td>
<td>1.72% (58)</td>
<td>4.19% (9)</td>
</tr>
<tr>
<td>PDR</td>
<td>0.31% (149)</td>
<td>0.32% (142)</td>
<td>0.15% (5)</td>
<td>0.93% (2)</td>
</tr>
<tr>
<td>PDR, high risk</td>
<td>0.00% (27)</td>
<td>0.00% (27)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Macular oedema</td>
<td>3.57% (1711)</td>
<td>3.62% (1605)</td>
<td>2.64% (89)</td>
<td>7.91% (17)</td>
</tr>
</tbody>
</table>

a Total number of examinations with no non-gradable photographs (used to calculate prevalences).

Table 1

Diabetic retinopathy (DR) screening results for all patients/examinations and according to screening site.

Taken, one centred on the macula and the other on the optic disc, as this method was considered to result in good sensitivity and cost-effectiveness [9,30,31]. Also, thanks to a standard communication procedure, GPs and endocrinologists were promptly informed of the screening results and could therefore adjust their treatments without delay. Screening by telemedicine was much less time-consuming for ophthalmologists than performing an ophthalmological examination [32]. Consequently, they can devote more time to treating their patients. In addition, telemedical screening has proved to be highly cost-effective [33]. The necessary software was also regularly updated as and when it was needed to improve the efficacy and security of the network.

In the present study, nearly three-quarters of the patients screened were asked to undergo annual screening by retinography during hospitalizations or consultations is much more convenient for them, as well as being more cost-effective. Pupil dilation before screening might be a solution in some of these cases. The remaining two-thirds of these patients were referred because they had more than mild DR, and suspected macular oedema or other eye disease such as glaucoma. This is all the information obtained on these referred patients, but further follow-up may be mandatory in a screening programme.

As regards the distribution of the present cohort of patients among hospitals and primary healthcare centres, the proportion of patients with type 1 diabetes or insulin-requiring type 2 diabetes was much higher in the former than in the latter. This finding was accompanied by a greater prevalence of DR among patients screened in hospitals than in those screened in primary healthcare centres. Interestingly, a larger proportion of the patients screened in prisons exhibited more advanced stages of retinopathy than did those screened in the other healthcare settings. Nevertheless, proliferative retinopathy was diagnosed in less than 1% of the entire population studied.

Numerous studies in the literature have reported their results for telemedical screening for DR, but with different results. Nathoo et al. [17], for example, examined 394 patients in rural Alberta (Canada) and found a DR prevalence of 27.7%, which was mild NPDR in 22.8%, and moderate NPDR and PDR in only 2%, while macular oedema was diagnosed in 3%.
reported prevalence of DR was similar to that of our present study, although their prevalence of mild retinopathy was higher. In a study published in 2009 by Vleming et al. [16], reporting on the screening results for 1393 patients in the Madrid (Spain) area, the prevalence of DR was 21%, including 9% mild, 9% moderate NPDR and only 1% severe NPDR cases. No cases of proliferative disease were found by screening, whereas macular oedema was diagnosed in 4.68%. Again, these results are similar to ours, possibly because of the similarity of the health profiles and medical care of patients living in urban areas, which differ from those of patients living in rural areas. Beynat et al. [13] and Gibalde et al. [18], who screened 1974 and 2444 patients, respectively, found a much lower prevalence of DR (5.2% and 9.36%, respectively) than in both our present study and the studies mentioned above. This may have been mostly due to differences in the populations screened, as their patients came voluntarily or were sent by their GPs or endocrinologists. However, those with more complicated diabetes that required follow-up in hospital were not included in the screening. Gomez-Ulla et al. [12] reported on the results of 70 patients screened at two hospital units in Santiago de Compostela (Spain) and found a DR prevalence of 48.31%, including mild DR in 24.58%, moderate DR in 25.42% and severe NPDR in 7.63%. This extremely high prevalence compared with that reported here and in the studies cited above may have been due to the hospital setting and method of patient selection.

A striking finding of the present study was the small number of patients screened at primary healthcare centres and prisons. In the latter, where the programme was shown to be cost-effective, the limited uptake may have been due to the lack of human resources [34]. However, in primary healthcare centres, the small uptake was more disappointing. These results highlight the need for an effective screening programme in which an appointment at least once a year is proposed to all diabetic patients, with a reminder sent in cases of absenteeism. Indeed, such a systematic screening programme has been shown to be effective: in the UK, where such a programme was set up a few years ago by its National Health Service, the objective of screening at least 80% of all eligible diabetic patients annually has been met [35].

In conclusion, the Ophdiat® network constitutes a reliable screening programme for DR that is suitable for use in various healthcare settings. It has also been well received by both patients and physicians. In view of the growing prevalence of diabetes, on the one hand, and the decreasing number of ophthalmologists and reduced healthcare budgets on the other, the continuing expansion of the telemedical network would appear to be highly desirable. Nevertheless, a proactive campaign directed by the national health authorities seems to be necessary to improve patient attendance at screening centres.

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- hôpital Robert-Debré, Paris: Pr J.C. Carel, Diabetology Department; Dr E. Bui Quoc Ophthalmology Department;
- hôpital Corbeil-Essonne: Dr G. Charpentier, Diabetology Department;
- hôpital de Dreux: Dr D. Charitanski, Diabetology Department;
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- Réseau Diaborne: Dr P. Lacote;
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Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.
Appendix A. Supplementary data

Supplementary material (Table S1) associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.diabet.2012.05.003.

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