Autoimmunity in hereditary retinal degenerations. 
II. Clinical studies: antiretinal antibodies and fluorescein angiogram findings

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SUMMARY  Testing by indirect immunofluorescence for the detection of antiretinal antibodies and 
lymphocyte stimulation for cell-mediated immunity to retinal antigens was performed on blood 
obtained from 59 patients with retinitis pigmentosa (RP) and 29 without RP who had other types of 
retinal disease. The results from the patients' immunological studies were correlated in a masked 
各国 with six parameters of the fluorescein angiogram: disc staining, peripapillary oedema, 
vascular arcade oedema, macular oedema, and focal vascular staining (late phases), and disc 
telangiectasia (early phases). Significant correlations for both groups together were found for IgG 
antiretinal antibody reactivity and macular oedema (p<0.038) and disc staining (p<0.033). The 
non-RP retinal disease group had more significant correlations, including IgG antiretinal antibody 
reactivity with vascular arcade oedema (p<0.018), disc staining (p<0.018), and peripapillary 
oedema (p<0.023); the RP patients had significant correlation with IgG reactivity and arcade 
oedema (p<0.045). With combinations of IgG, IgM, and lymphocyte reactivity various significant 
correlations were found with the fluorescein angiogram.

Numerous laboratory studies support the notion that 
a variety of acquired and hereditary retinal diseases 
have autoimmune components, and reports to date 
have emphasised the presence of cell-mediated 
immunity or antiretinal antibodies to various retinal 
antigens in these patients. Whether a pathological 
role is played by these antibodies or by lymphocytes 
showing sensitisation to retinal antigens has been 
more difficult to determine. Retinal tissue is rarely 
available for direct study, and indirect methods are 
usually employed to investigate the possibility of 
immunopathogenicity in the retinal degenerations.

Clinicopathological correlations have been 
attempted by several investigators. Dumonde et al. 
examined sera from patients with various forms of 
retinal vasculitis for the presence of complement and 
antiretinal antibodies.1 In addition to identifying 
immunological activity they also attempted to corre-
late its degree with the severity of the systemic and 
retinal vasculitis. In patients with only ocular involve-
ment retinal autoantibodies were found significantly 
more often those with severe retinal vasculitis than in 
those who had only mild to moderate disease.

Keltner et al. reported on a cancer patient with an 
unusual retinal degeneration whose serum antibodies 
were reactive with normal donor retinal tissue by the 
immunofluorescent complement fixation test.2

Numerous studies have established that patients 
with retinitis pigmentosa (RP) and other retinal 
dergnerations frequently have an immunological 
response to retinal antigens. Alterations in cell-
mediated as well as humoral immunity have been 
described. Brinkman et al.3 and Heredia et al.4 
described retinal antigen stimulation of lymphocytes 
from RP patients, and Char et al. found that lympho-
cytes from RP patients were significantly more 
cytotoxic in an assay against a retinoblastoma tissue 
culture cell line.5 Increased cellular immune respons-
iveness to the retinal S antigen has been found in RP 
patients6 as well as patients with retinal inflammatory 
diseases such as birdshot retinochoroidopathy7 and 
uveitis.8
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Hooks et al. recently reported subnormal levels of a lymphokine, interferon-gamma, a product of T lymphocytes from 12 patients with RP. No abnormality of humoral immunity or any increased incidence of infections was detected in these patients.

While Rahi reported increased serum IgM levels in RP patients, a similar study by Spiro et al. found no difference in serum IgM levels between RP patients and controls. Kumar et al. found antiretinal antibodies by the tanned red cell haemagglutination technique in 60% (15/25) of RP cases that they investigated. Spalton et al. using immunofluorescence techniques demonstrated the binding of sera from RP patients to rat photoreceptor cells.

Recently our group reported that 37% (43/116) of RP patients and 33% (21/64) of non-RP patients with other retinal disease had antiretinal antibodies by indirect immunofluorescent techniques compared with 2% (1/42) of controls. The same study showed that 19% (16/86) of RP patients and 18% (11/64) of non-RP patients with other retinal eye disease had sensitisation of lymphocytes to retinal antigens when tested with in-vitro transformation assays.

While all these studies strongly suggest that the immune system may have an active role in RP and other retinal degenerations, no study to date has demonstrated a clinical correlation between the presence of immunological response and an objective measure of the patient’s disease state.

To ascertain whether antiretinal antibodies and sensitised lymphocytes may have a pathophysiological role in RP and other retinal degenerations, we correlated in a double-masked fashion the fluorescein angiographic findings with the presence or absence of antiretinal antibodies and cell-mediated immunity to retinal antigens in patients with RP and with non-RP ocular disease.

Patients and methods

Fifty-nine patients with all types of RP and 29 with other types of retinal disease, a subset of a larger group previously reported, were examined to see whether the presence of antiretinal immune activity correlated with findings on the fluorescein angiogram. Indirect immunofluorescence staining for IgG and IgM antiretinal antibodies and lymphocyte in-vitro transformation assays to retinal antigens were performed by methods previously reported. Patients selected for study were all those in whom a fluorescein angiogram was obtained as part of their routine diagnostic investigation within two months of venepuncture for the immunological studies. In most cases the fluorescein angiogram was obtained on the same day as the venepuncture was performed, but a few patients had fluorescein angiograms performed on return visits or a few days after the initial visit if an appointment was not available the same day. Selection was not based on any knowledge of the blood results.

Patients with progressive panretinal degeneration and other ocular disorders were evaluated with a comprehensive medical, ocular, and family history (pedigree analysis), ophthalmic examination, and tests consisting of Goldmann visual fields, electroretinogram, dark adaptation final rod threshold, fundus photography, and fluorescein angiography. Patients with hereditary retinal degenerations were classified as precisely as possible by the above tests and examination. RP was diagnosed when the patient had a panretinal degeneration with progressive visual field loss, and an abnormal or unrecordable electroretinogram with no other inflammatory or toxic history to explain the retinal degeneration.

The patients were placed in the following RP subgroups: rod-cone and cone-rod degeneration subdivided by inheritance, and the specific RP types of choroideraemia, preserved para-arteriolar retinal pigment epithelium RP (PPRPE), pigmented paravenous retinochoroidal atrophy, and Usher syndrome. The classification was based on previously published methods and rationale. (Pigmented paravenous retinochoroidal degeneration has never been proved to be a hereditary disease but is probably a pattern of degeneration. Whether it should be classified as a form of retinitis pigmentosa is debatable. These patients were included in the RP section because their clinical and functional testing gave similar results to those of many patients with simplex RP. See Heckenlively and Kokame.) The designation of cone-rod degeneration was given if there was either electroretinographic evidence that the photopic electroretinogram was worse affected than the rod-isolated electroretinogram or that the final rod threshold was elevated less than 2-0 log units anywhere outside the macular area. Rod-cone degeneration was diagnosed if a patient’s scotopic electroretinogram was more abnormal than the photopic waveform or if the final rod threshold was elevated, typically 3-4 log units or more. In advanced cases of RP in which the visual field is less than 8° it may not be possible to state whether a patient has the rod-cone or cone-rod pattern of degeneration on the basis of the dark adaptation test alone.

The study was performed in a masked fashion such that the investigators evaluating the fluorescein angiograms had no knowledge of the immunological activity results and vice versa. Detailed methodology for our evaluation of antiretinal antibodies and lymphocyte sensitisation to retinal antigens has been previously published and will be described briefly. Sera from patients with RP and other types of ocular
disease were placed on normal human donor retinal sections, which were then washed and stained with fluorescein-conjugated goat antihuman IgG and IgM reagents. The sections were examined under a fluorescein microscope and graded for presence or absence of staining. Positive staining indicated the presence of IgG and/or IgM antigens in the patient's serum that bound antigens present on the sections. Peripheral blood lymphocytes obtained as previously described\(^1\) were incubated with T and B lymphocyte mitogens or retinal antigens. Tritiated thymidine was added four hours before harvesting. Sensitisation was expressed as a stimulation index, consisting of a ratio of counts per minute in the presence of antigen divided by counts per minute in the absence of antigen. A stimulation index >2·0 was considered an indication of cell-mediated activity against retinal antigen. Lymphocytes obtained from normal volunteers were used for controls for each method.

Six angiographic parameters were examined by two investigators: disc telangiectasia, disc staining, peripapillary oedema, arcade oedema, macular oedema, and focal vascular staining. The fluorescein angiographic parameters were scored (1) not present, (2) moderately present, and (3) markedly present. For statistical analysis the latter two groups were combined.

Disc telangiectasia, or dilatation of normal disc surface vessels, has been noted by us in a number of retinal dystrophies, in particular the cone-rod degenerations.\(^2\) These vessels can be identified by abnormal beading of the vessel walls and by the increased numbers of small vessels seen in the early phases of the fluorescein angiogram (Fig. 1).

Disc staining was evaluated on the late phases of the fluorescein angiogram; a positive finding was a brightly hyperfluorescent disc, often with overlying vitreal haze where fluorescein had escaped into the adjacent vitreous (Fig. 2).

Peripapillary oedema, evaluated on the late phases of the fluorescein angiogram, consisted or markedly hyperfluorescent areas covering at least five clock
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Fig. 4 Arcade oedema superiorly is particularly marked, though the retinal arcade inferiorly also shows hyperfluorescence. Some macular and peripapillary oedema is also present. Patient is a 35-year-old woman with advanced simplex retinitis pigmentosa.

hours in the retina adjacent to the disc margin (Fig. 3).

Arcade oedema, evaluated on the late phases of the fluorescein angiogram, was identified when hyperfluorescent areas were noted deep to and adjacent to the vascular arcades of the posterior pole (Fig. 4). No attempt was made to distinguish whether the leakage was derived from retinal vasculature or retinal pigment epithelium.

Macular oedema was evaluated on late phases of the fluorescein angiogram and consisted of either the

Fig. 5 Cystoid macular oedema, more in the paramacular region, is noted in this 43-year-old woman with advanced simplex retinitis pigmentosa. Diffuse retinal oedema in the superior arcade and marked oedema of the maculopapillary bundle can be seen.

traditional changes of cystoid macular oedema or diffuse hyperfluorescence of the posterior pole in the anatomical macular area (Fig. 5).

Vascular staining was noted on late phases of the fluorescein angiogram as focal, often pinpoint, areas of hyperfluorescence which could be seen in venous and arteriolar vessel walls (Fig. 6). Vascular staining was most easily seen in arcade and peripapillary area vessels (Fig. 7). At least two distinct focal areas of hyperfluorescence in a vessel wall were needed to call this parameter moderately present.

Fig. 6 Focal vascular staining consisting of focal areas of hyperfluorescence is seen in peripapillary retinal vessels as well as retinal veins and arteries superiorly (arrows) in a 23-year-old man with choroideraemia.

Fig. 7 Focal vascular staining in peripapillary retinal arteries (arrow), left eye, in a 42-year-old woman with advanced simplex retinitis pigmentosa. Severe diffuse retinal oedema is also present.
An evaluation of the statistical association between fluorescein findings and immunological indices was performed by the one-tail Fisher's exact test. Group comparisons, such as RP with non-RP and rod-cone with cone-rod degeneration, were made by the Mantel-Haenszel test for homogeneity of $\chi^2$.

Results

Numerous significant correlations were found for all patients and for non-RP patients as a group. The non-RP disease group showed more significant correlations than the patients with RP.

For all patients (Table 1) positive immunofluorescence for IgG antiretinal antibodies correlated significantly with macular oedema ($p<0.038$) and disc staining ($p<0.033$). A less significant correlation was noted between focal vascular staining ($p<0.068$) and presence of IgG, and between the lymphocyte stimulation test and macular oedema ($p<0.079$).

In an attempt to locate a cumulative effect, combinations of immunoglobulin activity and/or lymphocyte stimulation were tested for significance; IgG or IgM antibody staining correlated with disc staining ($p<0.05$). Combinations of positive IgG and IgM staining, and lymphocyte stimulation tests, resulted in some correlation with focal vascular staining ($p<0.07$).

A number of significant correlations were found in the non-RP disease group (Table 2). IgG antiretinal antibody correlated with arcade oedema ($p<0.018$), with disc staining ($p<0.018$), and with peripapillary oedema ($p<0.023$). IgM staining correlated with peripapillary oedema ($p<0.011$). For a cumulative effect both IgG and IgM correlated with arcade oedema ($p<0.023$), disc staining ($p<0.029$), and peripapillary oedema ($p<0.003$). Positive IgG, IgM, and lymphocyte stimulation tests together did not correlate significantly with any angiographic parameter. Attempts to subdivide the non-RP group between inflammatory and degenerative causes did not give significant results.

RP patients as a group had fewer correlations. IgG immunofluorescence correlated with arcade oedema ($p<0.045$), as did the combination for IgG and IgM antibodies and positive lymphocyte stimulation ($p<0.045$).

When the RP and non-RP groups were compared with each other, numerous significant differences appeared in correlations with arcade oedema and papillary oedema (Table 2).

RP patients were further compared by type of degeneration, that is, rod-cone and cone-rod, and were evaluated by analysis of variance with the non-RP patients (Table 3). The findings from the rod-cone degeneration patients were significant or nearly so in correlations with arcade oedema. The findings from the cone-rod degeneration patients correlated nearly significantly in test correlations with focal vascular staining. No correlation was found between specific RP type and autoimmune reactivity.

### Table 1  Correlation of immune reactivity with fluorescein angiographic parameters for all patients (RP and non-RP)

<table>
<thead>
<tr>
<th>Index of immune reactivity</th>
<th>Angiographic change</th>
<th>Significance (p value): Fisher's exact test</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgG antiretinal antibody</td>
<td>Macular oedema</td>
<td>$&lt;0.038$</td>
</tr>
<tr>
<td>IgG antiretinal antibody</td>
<td>Disc staining</td>
<td>$&lt;0.033$</td>
</tr>
<tr>
<td>IgG antiretinal antibody</td>
<td>Focal vascular staining</td>
<td>$&lt;0.068$</td>
</tr>
<tr>
<td>Lympocyte stimulation</td>
<td>Macular oedema</td>
<td>$&lt;0.079$</td>
</tr>
<tr>
<td>(to retinal antigens)</td>
<td>Disc staining</td>
<td>$&lt;0.053$</td>
</tr>
<tr>
<td>IgG or IgM antiretinal</td>
<td>Focal vascular staining</td>
<td>$&lt;0.070$</td>
</tr>
<tr>
<td>antibodies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IgG, IgM antiretinal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>antibodies and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lymphocyte stimulation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2  Correlation of immune reactivity with fluorescein angiographic parameters by groups (RP and non-RP)

<table>
<thead>
<tr>
<th>Index of immune reactivity*</th>
<th>Angiographic change</th>
<th>Level of significance (p value)</th>
<th>RP</th>
<th>Non-RP</th>
<th>Group difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgG</td>
<td>Arcade oedema</td>
<td></td>
<td>0.045</td>
<td>0.018</td>
<td>0.005</td>
</tr>
<tr>
<td>IgG</td>
<td>Disc staining</td>
<td></td>
<td>NS</td>
<td>0.018</td>
<td>NS</td>
</tr>
<tr>
<td>IgG</td>
<td>Peripapillary oedema</td>
<td></td>
<td>NS</td>
<td>0.023</td>
<td>0.042</td>
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<tr>
<td>IgG</td>
<td>Peripapillary oedema</td>
<td></td>
<td>NS</td>
<td>0.011</td>
<td>0.057</td>
</tr>
<tr>
<td>IgG or IgM</td>
<td>Arcade oedema</td>
<td></td>
<td>NS</td>
<td>0.023</td>
<td>0.011</td>
</tr>
<tr>
<td>IgG or IgM</td>
<td>Disc staining</td>
<td></td>
<td>NS</td>
<td>0.029</td>
<td>NS</td>
</tr>
<tr>
<td>IgG or IgM</td>
<td>Peripapillary oedema</td>
<td></td>
<td>NS</td>
<td>0.003</td>
<td>0.008</td>
</tr>
<tr>
<td>IgG, IgM, Lymph. stim.</td>
<td>Arcade oedema</td>
<td></td>
<td>0.045</td>
<td>NS</td>
<td>0.043</td>
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<tr>
<td>IgG, IgM, Lymph. stim.</td>
<td>Disc staining</td>
<td></td>
<td>NS</td>
<td>0.069</td>
<td>NS</td>
</tr>
<tr>
<td>IgG, IgM, Lymph. stim.</td>
<td>Peripapillary oedema</td>
<td></td>
<td>NS</td>
<td>NS</td>
<td>0.055</td>
</tr>
</tbody>
</table>

* IgG/IgM = positive IgG/IgM immunoglobulin indirect immunofluorescence. Lymph. stim. = lymphocyte stimulation by retinal antigens. NS = non-significant.
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Table 3  Correlation of immune reactivity with fluorescein angiographic parameters by retinitis pigmentosa degenerative type

<table>
<thead>
<tr>
<th>Index of immune reactivity*</th>
<th>Angiographic change</th>
<th>Level of significance (p value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IgG</td>
<td>Focal vascular staining</td>
<td>NS</td>
</tr>
<tr>
<td>Lymph. stim.</td>
<td>Arcade oedema</td>
<td>0-067</td>
</tr>
<tr>
<td>IgG, IgM, lymph. stim.</td>
<td>Arcade oedema</td>
<td>0-011</td>
</tr>
<tr>
<td>IgG, IgM, lymph. stim.</td>
<td>Focal vascular staining</td>
<td>NS</td>
</tr>
</tbody>
</table>

*IgG/IgM = positive IgG/IgM immunoglobulin indirect immunofluorescence. Lymph. stim. = lymphocyte stimulation by retinal antigens. NS = non-significant.

Discussion

While this study was originally designed to investigate the potential pathological role of the immune system in RP patients, the most significant results were found in the non-RP ocular disease reference group, which consisted mainly of other types of retinal disease (Table 4). These non-RP patients showed significant correlations between IgG and the combination of IgG and IgM antiretinal antibodies with arcade oedema, disc staining, and peripapillary oedema. IgM staining correlated significantly with peripapillary oedema.

RP patients as a group showed significant correlations between IgG alone and IgG, IgM antiretinal antibodies and lymphocyte stimulation with arcade oedema; when divided into rod-cone and cone-rod degeneration, neither group showed significant correlations singly with any immune index. Only the rod-cone degeneration group showed a significant correlation between the combination of IgG, IgM antiretinal antibodies and the lymphocyte stimulation test together as a cumulative effect with arcade oedema.

The existence of correlations between fluorescein angiographic changes and indices of immune activity may be an indication that the immune system has a pathophysiological role in a number of retinal diseases. This correlation does not clarify whether the observed changes represent a primary pathological process, a secondary effect in a complicated degenerative process, or possibly some type of epiphenomenon. The observation that RP patients show fewer such correlations than non-RP patients may not reflect a lack of immunological activity but rather that the slow degenerative process inherent in RP does not challenge the immune system in the same fashion as the process of inflammatory disease. Eye tissue compared with total body mass is small to begin with, and products from a retinal degeneration would not be a large antigenic challenge.

Fluorescein angiography is commonly used for investigating various types of retinal oedema and less commonly for disc telangiectasia. Focal vascular staining on late phases of the fluorescein angiogram is a finding not commonly associated with hereditary retinal degenerations, or even other retinal diseases except vasculitis. The cause of focal vascular staining is unknown, but it could be related to the presence of immune complexes or other immunological entity producing damage to retinal vessels.

Peripapillary oedema was significantly associated with both presence of antiretinal antibodies and lymphocyte sensitisation. Since the peripapillary area, particularly when a conus is present, tends to be unprotected by the blood-retinal and retinal pigment epithelial barriers, it is not surprising that antiretinal immunological mechanisms might damage this area.

The correlations between the fluorescein angiogram and markers of immune reactivity in this study lead us to assume that they reflect secondary rather than primary disease effects and that the pathological influence of immune factors remains to be determined. Indirect immunofluorescent staining with the use of patient sera on human donor tissue has proved valuable in detecting antiretinal antibodies, and it merits further investigation for its development as a possible clinical tool.

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References


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