Ocular manifestations of onchocerciasis in a rain forest area of West Africa

Henry S Newland, Albert T White, Bruce M Greene, Robert P Murphy, Hugh R Taylor

Abstract

The epidemiology and natural history of onchocerciasis and its ocular complications in rain forest areas are poorly understood. The present study was conducted on a rubber plantation in a hyperendemic area in the rain forest of Liberia, West Africa, where 800 persons were examined. The prevalence of infection was 84% overall 29% had intraocular microfilariae, and 2·4% were blind in one or both eyes. Onchocerciasis was the cause of all binocular blindness and one-third of all visual impairment. Over half of the visual impairment caused by onchocerciasis was due to posterior segment diseases. Chorioretinal changes were present in 75% of people, and included intraretinal pigment clumping in 52% and retinal pigment epithelium atrophy in 32%. Atrophy of the retinal pigment epithelium was associated with increasing age and severity of infection. Intraretinal pigment was strongly associated with anterior uveitis. There was a strong correlation between uveitis and the inflammatory chorioretinal sequelae: retinitis, intraretinal pigment, subretinal fibrosis, and optic neuropathy. These findings indicate that considerable visual impairment associated with rain forest onchocerciasis is common and is due largely to chorioretinal disease.

Onchocerciasis is a major public health problem in equatorial West Africa.[1] Furthermore, mortality in blind adults is, on average, three to four times greater than of people of the same age who can see.[2] Although much has been learned about the systemic manifestations of the disease and the ocular changes in the anterior segment, especially in savanna areas,[3,4] relatively little is known about the epidemiology and natural history of the ocular complications in rain forest areas of West Africa.

While onchocerciasis has been known to exist in Liberia since 1926,[5] the importance of its ocular sequelae was not initially appreciated. A small study in 1955[6] found little evidence for severe ocular disease and reported a prevalence of infection of 40%, with 10% of patients having ocular involvement. Another report in 1958 found a prevalence of infection of 69%, but no cases of blindness or obvious lesions due to onchocerciasis were found despite slit-lamp examination.[7] Another study reported that 49% of adults infected with *Onchocerca volvulus* had microfilariae in the lateral canthus of the eye, an indicator of ocular involvement.[8] Subsequent studies, however, have indicated that onchocerciasis is an important blinding disease in Liberia. In 1973, Frentzel-Beyme found significant ocular onchocerciasis and a blindness rate of 1·2% in the Bong Range.[9] This was double the rate found in areas of Liberia free of onchocerciasis. In 1978 Connor and coworkers reported chorioretinitis in 22% and a blindness prevalence of approximately 1% in northern Liberia.[10] Chorioretinitis has also been reported in a high proportion of patients studied in clinical trials in Liberia.[11]

We undertook a more detailed ocular survey of a population in a hyperendemic area of Liberia to provide further information on the epidemiology and natural history of anterior and posterior segment ocular disease in Liberia and on risk factors associated with those chorioretinal changes.

Materials and methods

CENSUS AND SAMPLING

Employees and their dependants on the Liberian Agricultural Company (LAC) Rubber Plantation in Grand Bassa County, Liberia, were chosen as the study population. A house-by-house census of 1997 people in 18 camps was taken, and the offer of participation in a clinical trial was made. A census card recording name, house, camp, age, sex, tribe, and occupation was completed for each person aged 12 years or more. Participants generally, lived within walking distance of the examination clinic, though transport was available when needed.

EXAMINATION PROCEDURE

Uncorrected and corrected visual acuity was tested by illiterate E chart at 6 m. If either acuity was <6/12, it was assessed with a pinhole. The visual fields were tested with a clear dome Goodlite perimeter with fibre optic target. Fields were recorded as normal, 40–20°, 20–10°, <10° residual field, or absent.

Before anterior segment examination with a Topcon SL5D slit-lamp the patient was positioned in the head-down position for at least two minutes. Then the number of live microfilariae in the anterior chamber was counted (MfAC).

On the basis of presence and extent of flare and cells in the anterior chamber, uveitis was graded as absent, mild, moderate, or severe. The numbers and locations of live and dead microfilariae and punctate opacities in the cornea were recorded. Limbitis was diagnosed by the presence of limbal vessel dilatation, limbal oedema, or white globular opacities. The severity of limbitis was graded as absent, mild, moderate, or severe. Sclerosing keratitis was graded as absent, limbal haze, stroma opacified, or vascularised in the nasal or temporal meridian,

Dana Center for Preventive Ophthalmology, Wilmer Institute, Johns Hopkins University, Baltimore, Maryland, USA
H S Newland
R P Murphy
H R Taylor

Division of Georgraphic Medicine, University of Alabama at Birmingham, Birmingham, Alabama, USA
A T White
B M Greene

Correspondence to:
H S Newland, MD,
Flinders Medical Centre,
Bedford Park,
South Australia 5042,
Australia.

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with or without confluence inferiorly, or completely covering the pupil. Intraocular pressure was measured on all patients over 30 years old with a Goldmann applanation tonometer. The remainder of the anterior segment structures were examined by the slit-lamp, and any other abnormalities were recorded.

After pupil dilatation with 1% tropicamide and 10% phenylephrine, direct and indirect ophthalmoscopy was performed, and fundal abnormalities were recorded. Colour photographs were taken of the Diabetic Research Study fields 1, 2, 3, and 8 (nasal to disc) with a Topcon FE fundus camera.[12] Subsequently the photographs were evaluated in a masked fashion with patient identity obscured. The chorioretinal changes were graded according to the presence and extent of retinal pigment epithelium atrophy, intraretinal pigment clumping, shiny and white intraretinal deposits, retinitis, subretinal fibrosis, and optic neuropathy (neuritis or atrophy); any other abnormalities were also noted.

A medical history was taken, and it included a review of the dermatological, cardiovascular, nervous, and lymphatic systems. A thorough physical examination was also performed with particular reference to the general appearance, location of nodules, lymphadenopathy, dermatological findings, and weight.

Skin biopsies were taken bilaterally with a Holth-type corneoscleral punch from the scapulae, upper buttocks, and calves. These were individually weighed and placed in a flat-bottom microtitre plate well containing 0·1 ml of tissue culture medium (Roswell Park Memorial Institute: RPMI) with penicillin (100 U/ml) and streptomycin (100 μg/mg.) Microfilariae were counted after overnight incubation, and the density of infection was expressed as number per mg of skin (MfS).

DATA ANALYSIS

The analyses included: (1) simple frequency distribution for descriptive analysis; (2) Student's t test for comparison between means; (3) χ^2 or Fisher's exact test for comparison of proportions; (4) Pearson's correlation for the computation of bivariate correlation; and (5) multiple regression for computation of the adjusted correlation coefficient.

Results

STUDY POPULATION

A total of 800 persons aged 12 years or more voluntarily reported for detailed physical, parasitological, and ocular examination. The mean camp size was 111, and the mean response rate was 40%. The age and sex distribution of those who were examined was the same as that for the general population, and no obvious sources of selection bias were seen (Table 1).

PREVALENCE AND INTENSITY OF INFECTION

The overall prevalence of infection was 84·3% (Table 2). The prevalence was uniformly high in all age groups and was similar for each sex. It was significantly higher in those who worked as rubber tappers (89·3%) than in those with any other occupation (<0·02).

Density of infection increased with age, and in males (6·5 microfilariae/mg) it was almost twice that in females (3·5 microfilariae/mg) (Table 2). Tappers were also the most heavily infected occupational group (8·6 microfilariae/mg) with students having the lowest density (3·9 microfilariae/mg).

BLINDNESS AND VISUAL IMPAIRMENT

The rates of blindness and visual impairment increased with age, with the highest rates occurring in people over 40 (Table 3). There were fewer blind males (1·6%) than blind females (3·9%). Although there was less blindness among the tappers (1·9%) than in other occupations (2·6%), more (1·4%) had low vision than did those with other occupations (1·2%).

Table 1 Age and sex distribution of census and study populations

Age (Years)	Male	Female	Total
Census Population			
12–19	280 (24·5%)	253 (29·6%)	553 (26·7%)
20–29	337 (29·5)	357 (41·8%)	694 (34·8%)
30–39	281 (24·6%)	185 (21·6%)	466 (23·3%)
40–49	161 (14·1%)	44 (5·1%)	205 (10·2%)
50+	83 (7·3%)	16 (1·9%)	99 (5·0%)
Total	1142 (100%)	855 (100%)	1997 (100%)
Study population			
12–19	146 (28·6%)	95 (32·9%)	241 (30·1%)
20–29	139 (27·2%)	96 (33·2%)	235 (29·4%)
30–39	111 (21·7%)	70 (24·2%)	181 (22·6%)
40–49	84 (16·4%)	20 (6·9%)	104 (13·0%)
50+	31 (6·1%)	8 (2·8%)	39 (4·9%)
Total	511 (100%)	289 (100%)	800 (100%)

Table 2 Prevalence and density of infection by age, sex, and occupation

Total	Number tested	Density positive	Prevalence MF/mg skin	(%)
Total	776*	654	5·3	84·3
Age				
12–19	229	184	4·0	80·4
20–29	231	199	5·1	86·2
30–39	175	145	5·5	82·9
40–49	103	92	8·1	89·3
50+	38	34	8·8	89·5
Sex				
Male	449	424	6·5	85·0
Female	277	230	3·5	83·0
Occupation				
Tapper	215	192	8·6	89·3
Housewife	186	161	4·4	86·6
Student	221	174	3·9	78·7
Other†	154	127	5·0	82·5

*Skin snips from 24 patients were mislaid. †other occupations included factory workers, drivers, teachers, and nurses.

Table 3 Proportion with monocular or binocular visual impairment by age, sex, and occupation

Total each group	Number 793‡	Blind* 19 (2·4%)	Low Vision† 10 (1·3%)
Age			
12–19	241	2 (0·8%)	4 (1·7%)
20–29	233	6 (2·6%)	2 (0·9%)
30–39	178	1 (0·6%)	2 (1·1%)
40+	141	10 (7·1%)	2 (1·4%)
Sex			
Males	509	8 (1·6%)	7 (1·4%)
Females	284	11 (3·9%)	3 (1·1%)
Occupation			
Tapper	215	4 (1·9%)	3 (1·4%)
Other (Combined)	578	15 (2·6%)	7 (1·2%)

*Blind: vision less than 3/60 in one or both eyes. †Low vision: less than 6/18 to 3/60 in one or both eyes. ‡Seven subjects were unable to comprehend the visual acuity test.

Table 4 Prevalence of monocular and binocular visual impairment by cause among study population

Cause	Binocular (better eye)		Monocular	
	Blind* Number (%)	Low vision† Number (%)	Blind Number (%)	Low vision Number (%)
Onchocerciasis	3 (0·4)	1 (0·1)	5 (0·6)	1 (0·1)
Glaucoma	0 (0·0)	1 (0·1)	2 (0·3)	0 (0·0)
Cataract	0 (0·0)	1 (0·1)	2 (0·3)	1 (0·1)
Toxoplasmosis	0 (0·0)	0 (0·0)	1 (0·1)	1 (0·1)
Trauma	0 (0·0)	0 (0·0)	4 (0·5)	0 (0·0)
Amblyopia	0 (0·0)	0 (0·0)	0 (0·0)	2 (0·3)
Refractive error	0 (0·0)	1 (0·1)	0 (0·0)	0 (0·0)
Other‡	0 (0·0)	1 (0·1)	2 (0·3)	0 (0·0)
Total	3 (0·4)	5 (0·6)	16 (2·0)	5 (0·6)

*Blind: vision less than 3/60. †Low vision: less than 6/18 to 3/60. ‡Other causes include measles, bush medicine, and corneal scarring.

Blindness is the most serious sequel of onchocerciasis, and the three people who were bilaterally blind (vision <3/60 in each eye) all had lesions attributable to onchocerciasis (Table 4). In addition, there were 16 people who were monocularly blind (vision <3/60 in the worst eye), and five of these were blind from onchocerciasis. Seven of those with monocular blindness had some visual impairment (vision <6/18) in the fellow eye. In four of these the visual impairment was due to onchocerciasis lesions. Five subjects (0·6%) had binocular low vision and five (0·6%) had monocular low vision. Thus 29 subjects had visual impairment in one or both eyes. In 9 (31·0%) this was attributed to onchocerciasis, and of those in whom blindness or low vision was due to onchocerciasis it was due to anterior segment disease in four (40·0%) and to posterior segment disease in six (60·0%).

ANTERIOR SEGMENT FINDINGS

MfAC were present in 191 (23·9%). The prevalence of microfilariae in the anterior chamber increased with age for both males and females (Fig 1). Live and dead microfilariae (MfC) were present in 13·6% of the population overall, but, except for an apparent increase in elderly women, there was less of an increase with age (Fig 2). The proportion of those with punctate corneal opacities was 19·1% overall, with no clear age or sex dependency, but again there was an increase

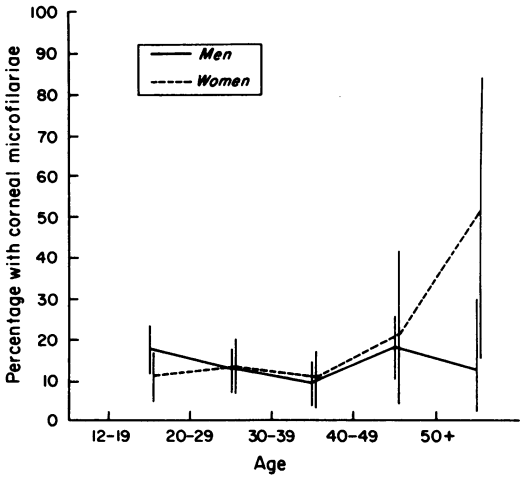

Figure 2 Proportion and 95% confidence limits of those with microfilariae in the cornea.

in prevalence in the older women (Fig 3). Sclerosing keratitis had an overall prevalence of 5% and was more common in the older subjects (Fig 4).

POSTERIOR SEGMENT FINDINGS

Chorioretinal changes were present in 596 (76·2%) of 782 subjects with readable fundus photographs (Fig 5–11). The commonest change was intraretinal pigment (IRP), which occurred in 405 patients (51·8%), while retinal pigment epithelium atrophy was found in 251 (32·1%). Less common were white intraretinal deposits in 168 (21·4%) and shiny intraretinal deposits in 79 (10·1%) of the patients (Table 5). On univariate analysis atrophy of retinal pigment epithelium was correlated with age, MfC, punctate corneal opacities, total number of nodules, MfS, sclerosing keratitis, and being a tapper. Age and MfC remained significantly correlated in multivariate analysis after controlling for other risk factors ($p<0·05$). Subretinal fibrosis and optic neuropathy were both associated with increasing age. Subretinal fibrosis, optic neuropathy, IRP, and retinitis were all associated with uveitis, and the correlation persisted for IRP and retinitis after multivariate analysis. IRP was also found in those with MfAC and a skin rash. Retinitis was

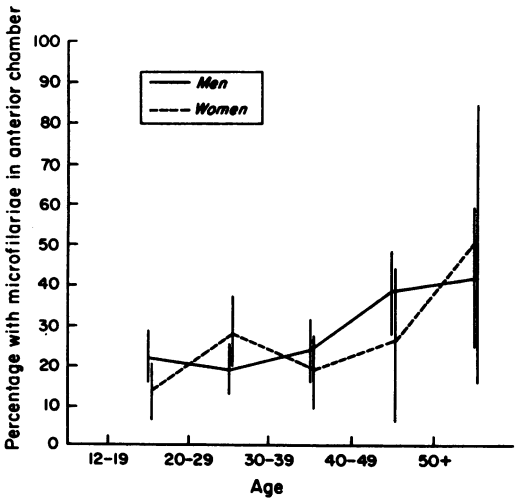

Figure 1 Proportion and 95% confidence limits of those with microfilariae in the anterior chamber.

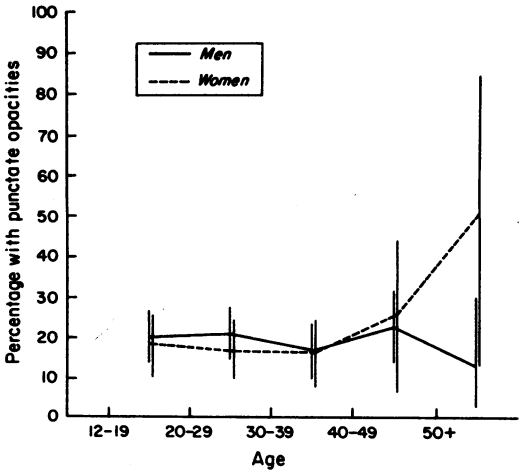

Figure 3 Proportion and 95% confidence limits of those with punctate opacities in the cornea.

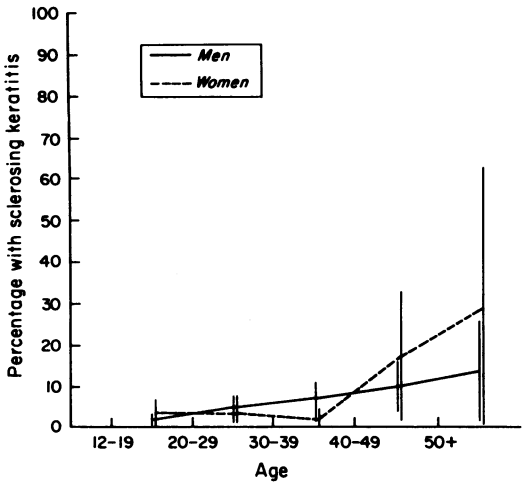

Figure 4 Proportion and 95% confidence limits of those with sclerosing keratitis.

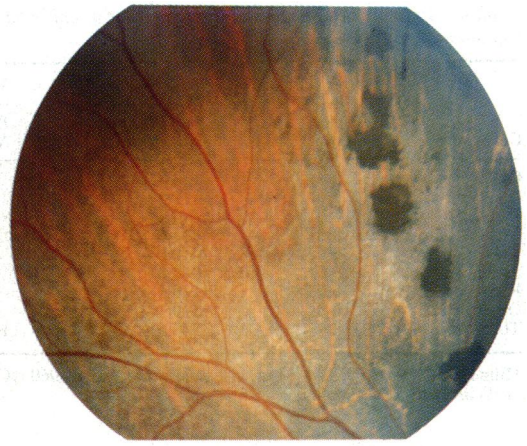

Figure 6 Severe chorioretinitis and intraretinal pigment clumping in a 19-year-old male with a mean skin snip count of 15 Mf/mg.

associated with prior treatment with diethylcarbamazine and with limbitis. White and shiny intraretinal deposits were weakly correlated with punctate opacities in the cornea.

All the people were classified on clinical and parasitological findings as to the overall likelihood of their actually having onchocerciasis. It should be remembered that they lived in an endemic area and were highly likely to have been exposed, if not infected. Those who had microfilariae in either the skin or the eye were classified as having definite onchocerciasis; those without skin or ocular microfilariae but who had punctate corneal opacities, sclerosing keratitis, charactersitic nodules, a history of previous treatment, or who had skin lesions consistent with onchodermatitis were classified as having probable onchocerciasis. People in whom all of the above criteria were negative were considered not to have onchocerciasis. Subretinal fibrosis and optic neuropathy were found only in those with definite onchocerciasis; retinitis, limbitis, and uveitis were found in those in the definite or probable groups (Table 6). Interestingly, atrophy of retinal pigment epithelium was common in each group but more prevalent in those patients with definite or probable onchocerciasis.

There was no correlation between onchocerciasis status and either age or sex, though a higher proportion of rubber tappers had onchocerciasis.

Discussion

Onchocerciasis was the main cause of bilateral blindness in this population. We found a high prevalence of ocular involvement and in particular a high prevalence of posterior segment changes. The examinations were in part carried out as a preliminary screen for clinical trial.[13 14] This may have introduced some bias, as it is possible that those who considered themselves healthy might see litttle purpose in participating. Indeed, we ascertained by interview that the requisite blood samples and skin biopsies were deterrents to participation for at least some people.

We found a prevalence of infection of 84%. This is higher than in a previous study in the area in 1975, which reported a prevalence of infection of only 63%,[15] but they took fewer skin snips. During the past 10 years there have been important changes in this area associated with the progressive development of the plantation,

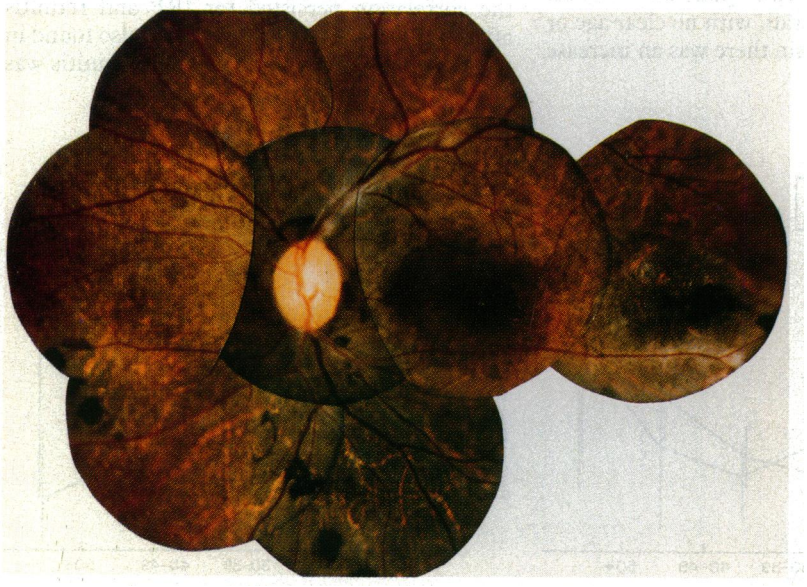

Figure 5 Montage of fundus showing discrete areas of retinal pigment epithelium atrophy (RPEA) and areas of RPE hypertrophy in a 19-year-old male with a mean skin snip count of 17 Mf/mg.

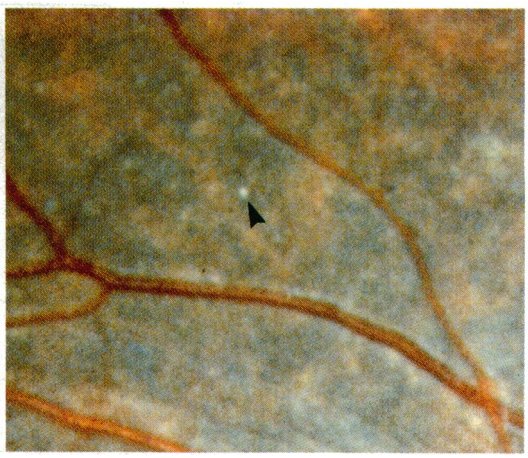

Figure 7 A shiny white deposit (arrow).

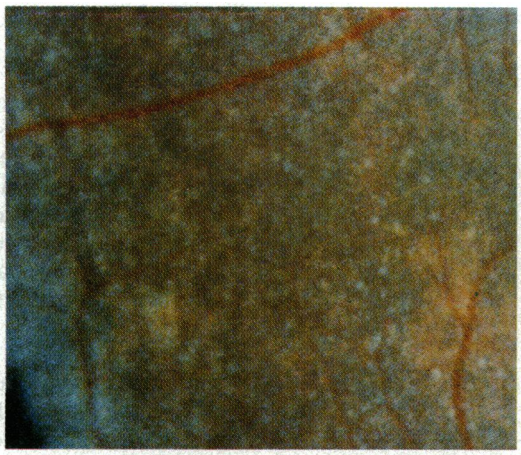

Figure 8 Multiple white intraretinal deposits temporal to the macula in a 19-year-old male with a mean skin snip count of 17 Mf/mg.

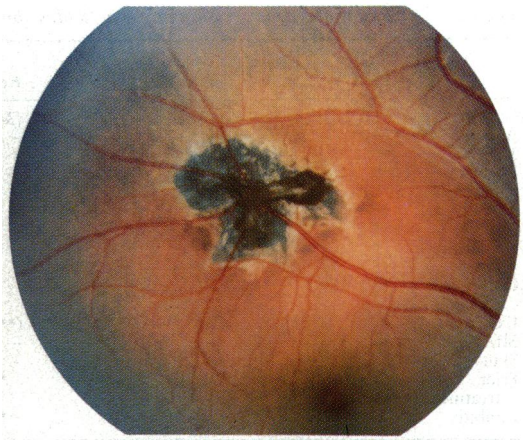

Figure 10 Area of subretinal fibrosis with overlying pigment in a 17-year-old male patient with a mean skin snip count of 6 Mf/mg.

which requires the recruitment of new workers, many of whom came from other hyperendemic areas.

The density of infection was especially high in males and tappers, who were also at higher risk of infection than other occupations. The tappers, who are mostly male, work among the rubber trees near the breeding sites and are more exposed to the biting black flies that transmit onchocerciasis. Their clothing, often minimal, offers little protection from the flies. It is interesting that there was not a correspondingly high proportion of blind tappers. Almost paradoxically, it was the elderly females who had the highest rate of blindness. This may be because tappers leave the plantation when their vision is so badly affected that they are no longer able to work. On the other hand the wives or female relatives of sighted male employees would remain for as long as their husbands worked, and this would artificially increase the numbers of visually impaired females.

The prevalence of bilateral blindness was also relatively low (0·4%) but it was all attributable to onchocerciasis. This rate is still twice that of most developed countries.[16] In other studies in rain forest areas, Anderson *et al* reported a 2·0% blindness rate from all causes in the Cameroon rain forest, three-fourths of which was due to onchocerciasis.[17] In Liberia, Frentzel-Beyme reported a 1·2% blindness rate among 285 persons in a rural area,[9] with the majority of blindness due to onchocerciasis. From a larger survey he later reported a 1·9% prevalence of blindness, with one-fourth attributable to onchocerciasis.[18]

The presence of microfilariae in the anterior chamber (MfAC) is often taken as a measure of ocular disease in onchocerciasis, but the validity of this as an indicator is limited by the relative difficulty in obtaining reproducible data unless the examination technique is standardised.[19] Prevalence figures for MfAC from various studies in Liberia show considerable differences for the data we report. Connor and coworkers found microfilariae in the anterior chamber in about 41% of their subjects,[10] while Frentzel-Beyme reported a prevalence of only 8·7%.[9] This lower figure is almost certainly due in part to the fact that the patients were examined without previous positioning with the head down.

In the present study, as in the Cameroon rain forest,[20] older women had a higher prevalence of corneal microfilariae and punctate opacities. Perhaps this is because the older women remain in the population longer, but hormonal factors have also been implicated. Anderson and coworkers suggest that a protective role is played by hormonal factors in females during their reproductive years.[20]

The prevalence of sclerosing keratitis was higher in our Liberian study (5%) than the 1·6%

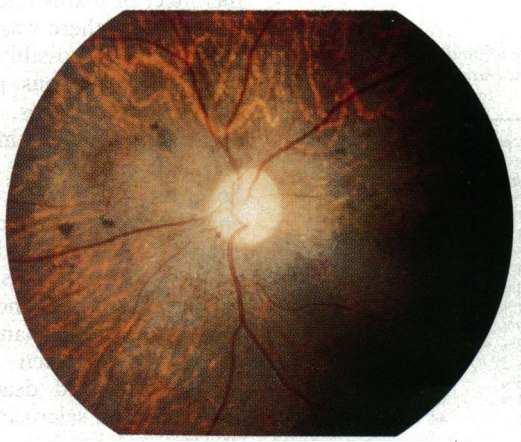

Figure 9 Advanced retinitis, IRP, RPEA, and otpic atrophy in a 30-year-old female with a mean skin snip count of 111 Mf/mg.

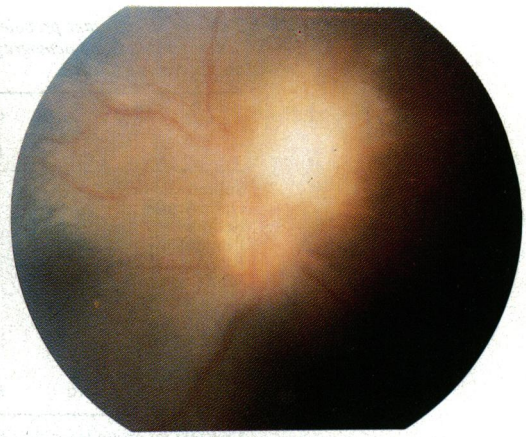

Figure 11 Large area of acute retinitis in a 14-year-old patient with a mean skin snip count of 9 Mf/mg.

Table 5 Univariate and multivariate analysis of fundus abnormalities

	RPEA†	Subretinal fibrosis	Optic neuropathy	IRP‡	Retinitis	White deposits	Shiny deposits
	(251)§	(8)	(8)	(405)	(34)	(168)	(79)
Age	(***)	***	**	–	–	–	–
MfC	(**)	–	*	–	–	–	**
Punctate opacities	**	–	–	–	–	*	*
Nodule total	**	–	–	–	–	**	–
MfS	*	–	–	–	–	–	–
Sclerosing keratitis	*	–	–	–	–	–	–
Occupation tapper	**	–	–	–	–	–	–
Uveitis	–	***	***	(**)	(**)	–	–
MfAC	–	–	–	**	–	*	–
Skin rash	–	–	–	*	–	–	–
Prior treatment	–	–	–	–	*	–	–
Limbitis	–	–	–	–	*	–	–

*p=0·09 to 0·05. **p=0·04 to 0·01. ***p<0·01. ( ) Significant after multivariate analysis, controlling for other risk factors. †Retinal pigment epithelium atrophy. ‡Intraretinal pigment. §Numbers in parentheses are numbers of people with fundus abnormality in one or both eyes.

prevalence found in the Cameroon rain forest.[20] Although the early stage of limbal haze was not classified as sclerosing keratitis in the Cameroon study, when Liberian subjects with limbal haze alone were excluded the overall prevalence still remained at 4·2%. Sclerosing keratitis was often seen in a milder form in the Liberian rain forest population than in the savanna, and in this population of largely able-bodied men it was associated with relatively little visual impairment. It was the cause of bilateral blindness in one patient, while secondary glaucoma caused blindness in another.

The advanced chorioretinal abnormalities associated with onchocerciasis have been described in detail,[21] but little is known about the earlier stages of ocular involvement. A high number of vitreoretinal changes were reported in a study of 30 Liberian men[11] who were examined in great detail with direct and indirect ophthalmoscopy, fundus photography, fluorescein angiography, and triple-mirror contact lens examination. Even in the present study, with a somewhat less detailed examination including only indirect ophthalmoscopy and fundus photography, the prevalence of chorioretinal changes was high.

The pathogenesis of the chorioretinal changes in onchocerciasis is not clear, and many theories have been advanced. In 1935 Bryant suggested that the adult worms secrete a systemic toxin which affects the fundus and optic nerve.[22] This type of process would be consistent with the bilateral symmetrical nature of the disease. Bryant also suggested that microfilariae invade the optic tract producing perivascular infiltration and bilateral symptoms.

In 1945 Ridley concluded from his own, and other, observations that dead microfilariae in the choroid cause occlusion of the smaller blood vessels and atrophy of the retina.[23] He also implicated perivascular infiltration and endothelial proliferation of the short ciliary vessels in the production of a diffuse choroidoretinal degeneration. In 1955 Budden echoed Bryant's suggestion that posterior segment damage might be due to the effects of toxins released by adult worms.[24] A combined effect of these toxins and avitaminosis A was postulated by Rodger,[25] whereas Choyce suggested that onchocercal chorioretinitis was only a genetic condition.[26] Neumann and Gunders suggested that the chorioretinal lesion was either due to an inflammatory reaction caused by the death of microfilariae in situ in the posterior segment or diffusion of toxic products from disintegrating microfilariae into the choroid and retina.[27] Garner suggested that the marked retinal and choriocapillaris atrophy was attributable to a preceding choroiditis.[28]

Although the precise mechanism is unknown, the role of systemic immune processes in pathogenesis of some of the complications of onchocerciasis has been established.[29-31] An association between circulating immune complexes and the occurrence of major ocular complications, including chorioretinitis, was reported.[32] Furthermore, circulating antibodies against various retinal antigens, including retinal S-antigen have been demonstrated in patients with retinopathy due to onchocerciasis.[33-35]

Donnelly and coworkers have demonstrated that chorioretinal changes similar to those in the human onchocerciasis occur in a monkey model after the vitreal injection of *O volvulus* microfilariae.[36] They suggested that the changes could be directly related to the presence of microfilariae in the retina. Microfilariae were found in the retina adjacent to the areas of retinal pigment epithelial changes, but with no surrounding inflammation. This would point to either a purely mechanical effect resulting from the passage of microfilariae through the retina or to the effect of toxins released by microfilariae. In their studies there was massive death of microfilariae and possibly an accumulation of microfilarial antigens, producing a change in the host immune status. This in turn could be followed by severe inflammation causing the tissue damage in the retina. Punctate corneal opacities, which are acute inflammatory foci enveloping dead microfilariae, demonstrate a similar chain of events in the anterior segment.

We conducted a risk factor analysis to gain further insight into the pathogenesis of some of the chorioretinal changes. We found a strong correlation between both anterior segment disease (live and dead microfilariae punctate opacities, and sclerosing keratitis) and systemic markers of cumulative disease (age, numbers of skin microfilariae, occupation, and total number of nodules). This suggests that similar

Table 6 Percentage prevalence of fundus abnormalities, ocular findings, and demographic characteristics by onchocerciasis status

	Total number	Onchocerciasis status*		
		Definite	Probable	None
Subretinal fibrosis	8	1%	0	0
Optic neuropathy	7	1%	0	0
Retinitis	34	5%	5%	0
Limbitis/uveitis	20	3%	2%	0
RPEA	248	34%	32%	22%
White deposits	158	21%	20%	22%
Shiny deposits	75	9%	18%	10%
IRP	395	52%	52%	53%
Mean age (years)		28·2	28·7	24·1
Males		66%	66%	59%
Rubber tappers†		21%	9%	3%
Total	756‡	641	44	71

*See text for grounds for classification. ‡Twenty four people had missing MfS values and 20 had unreadable photographs. †χ^2 test, p=0·001.

mechanisms are likely to cause both atrophy of retinal pigment epithelium and the anterior segment changes. The significance of the shiny, white intraretinal deposits seen in patients with onchocerciasis in unclear. These lesions were correlated with punctate opacities and may point to an inflammatory aetiology. It is possible that they represent the retinal equivalent of the corneal lesions and are small focal areas of inflammation surrounding dead or dying microfilariae; it may not be possible to determine their exact nature until further histopathological material is available.

The impact of onchocerciasis in rain forest areas in terms of visual impairment has often been underestimated, but our results suggest it is of considerable importance. Most posterior segment changes in onchocerciasis threaten sight and may cause irreversible damage. Further studies are needed to identify risk factors for chorioretinitis in hyperendemic areas and to treat as early as possible so that some visual loss may be prevented.

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