

# OPHTHALMIC MANIFESTATIONS IN LYME BORRELIOSIS

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## ABSTRACT

Lyme Borreliosis is a multisystem disorder caused by the spirochete *Borrelia burgdorferi*. Although many ocular manifestations have been attributed to Lyme Borreliosis, they remain a rare clinical feature of the disease. The spirochetes invade the eye early and remain dormant, accounting for both early and late ocular manifestations which range from conjunctivitis and keratitis to intraocular inflammatory syndromes and neuro-ophthalmic manifestations. Especially in endemic areas, ophthalmologists need to be aware of *Borrelia burgdorferi* as a possible causal agent. The aim of this article is to present a short review of ophthalmic disorders resulting from *Borrelia burgdorferi* infections.

## KEY WORDS

*Borrelia burgdorferi*, Lyme Borreliosis, eye, ophthalmic manifestations

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## INTRODUCTION

There has been a growing awareness of Lyme Borreliosis (LB) during recent years. *Borrelia burgdorferi* (*Bb*) infection can be associated with a variety of signs and symptoms including neurologic, dermatologic, cardiac and ophthalmic disorders. The infectious agent causing LB is the spirochete *Bb* which is transmitted by ixodid ticks (1,2). Recently, *Bb* has also been found in mosquitoes and deer flies (3).

The clinical course of LB is divided into three stages (4,5). Stage I directly follows the bite by an infected tick. Patients develop a typical skin lesion, erythema migrans (EM) (6) and, in some cases, non-specific influenza-like symptoms and fever. After several weeks, spirochetes spread throughout the body and patients may develop neurological, skin

and cardiac manifestations (Stage II) (4,7-9). Stage III is mainly characterized by polyarthritis, progressive encephalomyelitis similar to multiple sclerosis (4,5,8) and skin disorders with acrodermatitis chronica atrophicans (10). However, not every patient follows this course (6,11,12). In fact, no clear line can be drawn between the three stages, neither with respect to time of occurrence nor to symptoms.

*Bb* has been isolated from blood, cerebrospinal fluid and various tissues (7,13). Although *Borrelia* has also been identified histologically in the iris, the retina and in the vitreous humour (14-19), little attention has been focused on the ophthalmic manifestations of LB. Since LB can be associated with a number of ophthalmic manifestations, *Bb* should be considered as a possible causal agent. However, strict criteria should be applied to avoid

overdiagnosis. The aim of this article is to review the reported ophthalmic disorders associated with *Bb* infection.

## OPHTHALMIC MANIFESTATIONS OF BORRELIA BURGdorFERI INFECTION

### 1. OPHTHALMIC MANIFESTATIONS IN STAGE I (SEE TABLE 1)

1.1. Conjunctivitis, periorbital edema (5,13,18,20,21) Follicular conjunctivitis with photophobia and periorbital edema have been observed in 10% of patients in the early stages of LB.

### 2. OPHTHALMIC MANIFESTATIONS IN STAGE II (SEE TABLE 1)

#### 2.1. UVEITIS

2.1.1. Iridocyclitis (5,17-20, 22-37): Several case reports of LB and granulomatous iritis with posterior synechia have been published. Kauffmann and Wormser showed that panuveitis with disseminated chorioretinitis may follow iridocyclitis (19).

2.1.2. Pars planitis (25,27,28,31,35,38-40): Chronic intermediate uveitis with classic snowbanking and severe cystoid macular edema was reported by Breeveld et al. (38). In spite of the fact that the patient had suffered for 10 years, the ocular symptoms responded promptly to intravenous antibiotic therapy. Another case of pars planitis associated with facial palsy was presented by Winward et al. (35).

2.1.3. Vitritis (15,22,27,28,35,38,41-43): Several case reports of vitritis have been described. In 1991 Rothova et al. reported a case of spiderweb vitritis in the Lancet (43). Although it is only one single case report, it demonstrates the variety of ophthalmic manifestations of LB. Kuiper et al. observed vitritis in association with Lyme meningitis and cranial polyneuritis 6 weeks after a tick bite causing EM (42). Winward et al. described several patients with positive laboratory findings of borreliosis who had recurrent bilateral vitritis and granulomatous iridocyclitis relatively resistant to therapy (35).

2.1.4. Chorioretinitis (5,15,22,31,44,45): Two cases of bilateral diffuse chorioiditis, cystoid macular edema and exudative retinal detachment have been described. These patients also suffered from lymphocytic meningitis secondary to LB. The dramatic improvement of ocular complaints in these patients after doxycycline therapy suggests LB as a possible cause.

2.1.5. Pigmentepitheliitis (16,33,46,47): Bialasiewicz et al. observed a patient with hyper- and depigmentations in the macular region in association with *Bb* seroconversion (46). It was similar to pigmentepitheliitis. Recently, Wiegand described cases of presumed acute multifocal posterior placoid pigmentepitheliopathy in association with LB (33,47). Further investigations need to prove the relevance of this coincidence.

2.1.6. Retinal vasculitis (5,22,28,31,37,48): Several cases of retinal vasculitis in LB associated with vitritis and pars planitis have been presented. One patient with positive *Bb* serology developed retinal neovascularization and cystoid macular edema. He received oral tetracycline therapy and showed marked improvement. In two other cases of severe retinal vasculitis associated with *Bb* infection, surgical therapy was applied after antibiotic treatment was unsuccessful (28). Retinal vasculitis can be expected to occur in LB as similar findings are frequently seen in the later stages of syphilis, another spirochetal infection (28).

#### 2.2. Endophthalmitis (17,19)

Kauffmann et al. described a patient who showed severe unilateral panendophthalmitis following an insect bite causing EM (19). A lensectomy and vitrectomy were performed; Lyme spirochetes were found in the vitreous specimens.

#### 2.3. Neuro-ophthalmic manifestations

##### 2.3.1. Optic neuropathy

2.3.1.1. Optic neuritis (5,8,16,18,22,24,29,31,35,49-51): To date, there are only a few reports of optic neuritis associated with LB. Winward et al. observed a case of bilateral optic neuritis and mild vitritis (35). In these patients, central scotoma and afferent pupillary defect were present as well as other neurologic manifestations.

2.3.1.2. Anterior ischemic optic neuropathy (32,34, 52,53): A case of ischemic optic neuropathy secondary to LB with an inferior altitudinal field defect was reported by Schechter et al. (53). Pizzarello et al. described another case of ischemic neuropathy following a tick bite causing EM (52). Temporal artery specimens showed the typical appearance of giant cell arteritis, but a silver stain suggested spirochetes within the multinucleated giant cells. Ceftriaxone therapy led to a marked improvement of visual acuity.

2.3.1.3. Optic atrophy (11,18,20,25,34,48,54,55): Optic

Table I. Ophthalmic manifestations of Lyme Borreliosis by stage.

Ocular symptoms	Systemic symptoms	Routine serology
<b>Stage I (4-8 weeks)</b>		
conjunctivitis periorbital edema photophobia	primary affect erythema migrans lymphadenosis cutis benigna generalization fever, malaise, cephalaea	IgG negative IgM negative
<b>Stage II (&lt; 1 year)</b>		
uveitis iridocyclitis pars planitis vitritis chorioretinitis pigmentepithelitis AMPPPE* retinal vasculitis endophthalmitis neuro-ophthalmic manifestations optic neuropathy optic neuritis ischemic neuropathy optic atrophy papilledema pseudotumor cerebri Leber's neuroretinitis cranial nerve palsy oculomotor palsy (III, IV, VI) facial nerve palsy pupillary disorders Argyll Robertson pupil Horner's Syndrome paralytic mydriasis	organic manifestations dermatologic multiple erythemata neurologic meningitis radiculoneuritis cranial neuritis cardiac myocarditis pericarditis atrioventricular block rheumatologic mono-, oligoarthritis	IgG increasing IgM high
<b>Stage III (&gt; 1 year)</b>		
keratitis interstitial keratitis peripheral ulcerative keratitis episcleritis myositis neuro-ophthalmic manifestations optic neuritis ocular nerve palsies visual field defects nystagmus	organic manifestations dermatologic acrodermatitis chronica atrophicans neurologic progressive encephalomyelitis rheumatologic oligo-, polyarthritis chronic erosive arthritis	IgG high IgM low

\*AMPPPE = acute multifocal posterior placoid pigmentepitheliopathy

neuritis, ischemic neuropathy and chronic papilledema in pseudotumor cerebri may each be responsible for optic disc atrophy in patients with chronic LB. Bertuch et al. described a case of progressive optic disc pallor following a presumed diagnosis of LB without previously observed optic nerve disorders (55).

2.3.1.4. Papilledema (5,11,18-20,27,35,37,39,48,49,51,56-58): Optic disc edema may result from various causes. Only a minority of patients with Lyme meningitis develop disc edema. The latter leads to blurred vision and is usually not associated with elevated intracranial pressure (39). Optic perineuritis (11,18,19,57) is probably the reason for disc swelling in the cases described by Kauffmann et al. and Reik et al. (11,19). LB associated pseudotumor cerebri with increased cerebrospinal fluid pressure has been reported in several cases (35,49,56-58).

2.3.1.5. Leber's stellate neuroretinitis (5,20,48,49,59,60): This disorder is caused by vasculitis of the optic nerve head, causing distinct disc edema, venous congestion and star-shaped lipid exudation. It has been reported in viral diseases and neurolyues. Recently, a few cases of Leber's stellate neuroretinitis in LB have also been observed (59).

### 2.3.2. CRANIAL NEUROPATHY

2.3.2.1. Facial nerve palsy (8,11,27,28,35,49,51,54,56,61-65): Facial nerve palsy, occasionally associated with exposure keratitis, is the most common cranial neuropathy occurring in approximately 50% of patients with Lyme meningitis. Sometimes it is the only manifestation of the disease, although multiple recurrences have also been observed (35).

2.3.2.2. Oculomotor palsy (8,9,11,24,30,31,35,42,49,51,62,63,66,67): Cranial neuropathy with oculomotor, trochlear and abducens nerve palsies have been reported. Diplopia is the typical ocular complaint in this case. These palsies may occur individually or in combination with other neurologic abnormalities. LB has been reported in children suffering from late onset strabismus and diplopia (31,66).

### 2.3.3. Pupillary disorders (11,22,68)

In the literature, there are only anecdotal reports about the association of pupillary dysfunction and LB. Argyll-Robertson pupil was described in Reik's report in 1986 (11). This disorder is also common in neurolyues. A case with reversible Horner's Syndrome was observed by Glauser et al. (68). Karma et al. reported a case of bilateral paralytic mydriasis (22).

## 3. OPHTHALMIC MANIFESTATIONS IN STAGE III (SEE TABLE 1)

### 3.1. CONJUNCTIVITIS AND EPISCLERITIS (51,69-71)

Zaidman observed a case of chronic LB with tarsoconjunctival scarring, symblepharon and episcleritis (71). These manifestations are common in autoimmune eye diseases. Thus, an immune-pathogenesis can also be considered in this case of late LB.

### 3.2. KERATITIS

3.2.1. Interstitial keratitis (5,19,31,49,55,69,70,72-77): Interstitial keratitis in chronic spirochetal infections (*Treponema pallidum*) is well known. In LB, several cases with scattered hazy infiltrates of the deep and superficial stroma have been observed. Only one patient, however, exhibited corneal neovascularization unlike the typical syphilitic keratitis parenchymatosa with early stromal vascularization (19,74). It is interesting to note that these cases of Lyme-associated interstitial keratitis responded to local steroids but not to antibiotic therapy, thus suggesting an immunopathologic origin (74).

3.2.2. Peripheral ulcerative keratitis: A patient with peripheral ulceration secondary to LB was presented (78). It should be mentioned that this manifestation is commonly seen in autoimmune diseases.

### 3.3. ORBITAL MYOSITIS (79)

A single case of orbital myositis was described in the literature: a five year-old girl with typical manifestations of late LB. This child developed unilateral orbital pain, proptosis and diplopia. Computerized tomography disclosed myositis of the medial and inferior rectus muscle and haziness of the retrobulbar fat. Complete resolution was seen after corticoid therapy.

### 3.4. NEURO-OPHTHALMIC MANIFESTATIONS

The typical CNS manifestation in chronic LB is a progressive encephalomyelitis with fatigue, dementia, multiple cranial nerve palsies as well as cerebellary and extrapyramidal defects and recurrent strokes (80). These disorders are thought to be caused by occlusive cerebral vasculitis (5). MRI scanning shows multiple paraventricular and subcortical demyelinating lesions (5,11,16,18,48,49) similar to those seen in multiple sclerosis. Ocular symptoms in progressive encephalitis

are visual field defects, diplopia and/or nystagmus depending on the site of the cerebral lesions.

## CONCLUSION

Ophthalmic manifestations of LB are common and can mimic features of other systemic disorders. A variety of ocular disorders can be found in each stage of LB. The growing awareness of *Bb* infections has certainly contributed to improved diagnosis, but there are still diagnostic difficulties. Especially in cases with uveitis, optic neuritis or oculomotor nerve palsies, it is necessary to consider *Bb* as a possible causal agent (35). It is advisable to investigate the possible history of tick bites, EM and diseases such as arthritis. However, 30% - 40% of cases may show no history of tick bites. Serological tests for *Bb* antibodies can be helpful to support the clinical diagnosis of LB, but one must be aware of the fact that, in endemic areas, positive IgG titres may be an occasional coincidence. On the other hand, a negative result does not necessarily exclude the diagnosis in any clinical situation. Depending on the test used, LB may be seronegative in up to 50% (34,81). In cases with neuro-ophthalmic involvement, an examination of the CSF is recommended (66). In some cases of severe intraocular inflammation, a vitreous tap is required for diagnosis (20), however, it is difficult to prove *Bb* infection histologically. Rigorous criteria should be applied in order to avoid an overdiagnosis of the ocular manifestations of LB (30). The U.S. Centers for Disease Control proposed the definition of LB, as shown in Table 2 (30).

The postulated pathophysiologic mechanism of the disease is the direct bacterial invasion of the tissue

and subsequent immunologic reactions resulting in vascular occlusions in chronic stages of the disease (7,31,74). *Bb* has been cultured from blood, cerebrospinal fluid and directly from brain parenchyma (7,13,49), but it has also been identified histologically in the iris, the retina and in the vitreous humour (14-19). The immunological reactions which are believed to play a predominant role in chronic LB (31,74), however, have not been elucidated in detail as of yet.

In early LB oral antibiotic therapy shortens the duration of systemic symptoms and prevents the development of delayed disease in most patients. The specific recommendations for antibiotic therapy have changed over the past few years, but treatment failures have occurred with every regimen. Oral tetracycline or penicillin are the current recommended drugs for Stage I of LB. In later stages parenteral antibiotics, such as penicillin or cephalosporins, are required (12,18,30,34). The use of corticosteroids in chronic LB is controversial. Steroids apparently have been helpful in treating keratitis, myositis and certain neurologic symptoms in Stage III of LB (12,55,74,76,79). However, caution should always be taken when using steroids in LB, since they may cause severe exacerbation of all the clinical symptoms. Once *Bb* infection is diagnosed, steroids should only be used together with high doses of intravenous antibiotics, even in the late stages of LB.

The increasing number of reports of Lyme associated ocular disorders should alert ophthalmologists to consider *Bb* as a possible causal agent. Serologic investigations for Lyme antibodies are recommended in cases with ocular inflammatory diseases, optic neuropathies and cranial nerve palsies. In complex cases interdisciplinary cooperation with neurologists and infectious disease specialists is crucial.

Table II. Diagnostic criteria for Lyme Borreliosis according to the U.S. Centers for Disease Control (30).

Area	Criteria
endemic	<ol style="list-style-type: none"> <li>1. Erythema migrans with exposure not more than 30 days prior to onset</li> <li>2. Involvement of one organ system* and positive antibody test</li> </ol>
nonendemic	<ol style="list-style-type: none"> <li>1. Erythema migrans with positive antibody test</li> <li>2. Erythema migrans with involvement of two organ systems*</li> </ol>

\* musculoskeletal, neurologic, cardiac

## REFERENCES

1. Burgdorfer W, Barbour AG, Hayes SF et al. Lyme disease - a tick-borne spirochetosis? *Science* 1982; 216: 1317-19.
2. Steere AC, Grodzicki RL, Kornblatt AN et al. The spirochetal etiology of Lyme disease. *N Engl J Med* 1983; 308: 733-40.
3. Spalton DJ. Lyme disease. *Br J Ophthalmol* 1990; 74: 321-22.
4. Ackermann R. Erythema migrans Borreliosis and FSME. *Dtsch Ärzteblatt* 1986; 83: 1765-74.
5. Bialasiewicz AA. Augenbefunde bei Lyme-Borreliose. *Ophthalmologie* 1992; 89: 47-59.
6. Barbour AG. Isolation and cultivation of Lyme disease spirochetes. *Yale J Biol Med* 1984; 57: 521-25.
7. Duray PH, Steere AC. Clinical pathologic correlations of Lyme disease by stage. *Ann NY Acad Sci* 1988; 539: 65-79.
8. Pachner AR. Spirochetal diseases of the central nervous system. *Neurologic Clin* 1986; 4: 207-22.
9. Pachner AR, Steere AC. The triad of neurologic manifestations of Lyme disease: meningitis, cranial neuritis, and radiculoneuritis. *Neurology* 1985; 35: 47-53.
10. Steere AC. Lyme disease. *N Engl J Med* 1989; 321: 586-96.
11. Reik L, Burgdorfer W, Donaldson JO. Neurologic abnormalities in Lyme disease without erythema chronicum migrans. *Am J Med* 1986; 81: 73-78.
12. Winterkorn JMS. Lyme disease: neurologic and ophthalmic manifestation. *Surv Ophthalmol* 1990; 35: 191-204.
13. Steere AC, Bartenhagen NH, Craft JE et al. The early clinical manifestations of Lyme disease. *Ann Intern Med* 1983; 99: 76-82.
14. Preac-Mursic V, Pfister HW, Spiegel H et al. First isolation of *Borrelia burgdorferi* from an iris biopsy. *J Clin Neuro Ophthalmol* 1993; 13: 155-61.
15. Schubert HD, Greenebaum E, Neu HC. Cytologically proven seronegative Lyme choroiditis and vitritis. *Retina* 1994; 14: 39-42.
16. Karma A, Pirttila TA, Viljanen MK et al. Secondary retinitis pigmentosa and cerebral demyelination in Lyme Borreliosis. *Br J Ophthalmol* 1993; 77: 120-22.
17. Steere AC, Duray PH, Kauffmann DJH et al. Unilateral blindness caused by infection with the Lyme disease spirochete, *Borrelia burgdorferi*. *Ann Intern Med* 1985; 103: 382-84.
18. Farris BK, Webb RM. Lyme disease and optic neuritis. *J Clin Neuro Ophthalmol* 1988; 8: 73-78.
19. Kauffmann DJH, Wormser GP. Ocular Lyme disease: case report and review of the literature. *Br J Ophthalmol* 1990; 74: 325-27.
20. Lesser RL. Ocular manifestations of Lyme disease. *Am J Med* 1995; 98: 60-62.
21. Mombaerts IM, Maudgal PC, Knockaert DC. Bilateral follicular conjunctivitis as manifestation of Lyme disease. *Am J Ophthalmol* 1991; 112: 96-97.
22. Karma A, Seppala I, Mikkila H et al. Diagnosis and clinical characteristics of ocular Lyme Borreliosis. *Am J Ophthalmol* 1995; 119: 127-35.
23. Breeveld J, Kuiper H, Spanjaard L et al. Uveitis and Lyme Borreliosis. *Br J Ophthalmol* 1993; 77: 480-81.
24. Reim H, Reim M. Ocular findings in infections with *Borrelia burgdorferi*. *Klin Monatsbl Augenheilkd* 1992; 201: 83-91.
25. Culbertson WW, Winward K, Smith JL. Ocular Lyme Borreliosis. *Fortschr Ophthalmol* 1991; 88 (suppl. II): 439.
26. Isogai E, Isogai H, Kotake S et al. Detection of antibodies against *Borrelia burgdorferi* in patients with uveitis. *Am J Ophthalmol* 1991; 112: 23-30.
27. Smith JL. Neuro-ocular Lyme Borreliosis. *Neurol Clin* 1991; 9: 35-53.
28. Smith JL, Winward KE, Nicholson DF et al. Retinal vasculitis in Lyme Borreliosis. *J Clin Neuro Ophthalmol* 1991; 11: 7-15.
29. Boutros A, Rahn E, Nauheim R. Iritis and papillitis as a primary presentation of Lyme disease. *Ann Ophthalmol* 1990; 22: 24-25.
30. Aaberg TM. The expanding ophthalmologic spectrum of Lyme disease. *Am J Ophthalmol* 1989; 107: 77-80.
31. Fujikawa LS. Advances in immunology and uveitis. *Ophthalmology* 1989; 96: 1115-20.
32. Smith JL, Parson TM, Paris Hamelin AJ et al. The prevalence of Lyme disease in a nonendemic area. *J Clin Neuro Ophthalmol* 1989; 9: 148-55.
33. Wiegand W. Ocular findings in borreliosis -

- bilateral panuveitis with exudative retinal detachment. Fortschr Ophthalmol 1989; 86: 659-62.
34. Winward KE, Smith JL. Ocular disease in Caribbean patients with serologic evidence of Lyme Borreliosis. J Clin Neuro Ophthalmol 1989; 9: 65-70.
35. Winward KE, Smith JL, Culbertson WW et al. Ocular Lyme Borreliosis. Am J Ophthalmol 1989; 108: 651-57.
36. Zierhut M, Kreissig I, Pickert A. Panuveitis with positive serological tests for syphilis and Lyme disease. J Clin Neuro Ophthalmol 1989; 9: 71-75.
37. Wu G, Lincoff H, Ellsworth RM et al. Optic disc edema and Lyme disease. Ann Ophthalmol 1986; 18: 252-55.
38. Breeveld J, Rothova A, Kuiper H. Intermediate uveitis and Lyme Borreliosis. Br J Ophthalmol 1992; 76: 181-82.
39. Guex-Crosier Y, Herbort CP. Ocular Lyme disease in Switzerland. Klin Mbl Augenheilk 1992; 200: 545-46.
40. Nolle B. Serological evidence of an association between Lyme Borreliosis and intermediate uveitis. Dev Ophthalmol 1992; 23: 115-17.
41. Suttorp-Schulten MS, Kuiper H, Kijlstra A et al. Long-term effects of ceftriaxone treatment on intraocular Lyme Borreliosis. Am J Ophthalmol 1993; 116: 571-75.
42. Kuiper H, Koelman JH, Jager MJ. Vitreous clouding associated with Lyme Borreliosis. Am J Ophthalmol 1989; 108: 453-54.
43. Rothova A, Kuiper H, Spanjaard L et al. Spiderweb vitritis in Lyme Borreliosis. Lancet 1991; 337: 490-91.
44. Wilk CM, Bialasiewicz AA, Ruprecht KW et al. Bilateral acute confluent disseminated choroiditis in *Borrelia burgdorferi* infection. Klin Mbl Augenheilk 1989; 194: 88-96.
45. Bialasiewicz AA, Ruprecht KW, Naumann GOH et al. Bilateral diffuse choroiditis and exudative retinal detachments with evidence of Lyme disease. Am J Ophthalmol 1988; 105: 419-20.
46. Bialasiewicz AA, Schönherr U. Choriocapillaritis (Pigmentepithelitis) in *Borrelia burgdorferi* seroconversion. Klin Mbl Augenheilk 1990; 196: 481-83.
47. Tonjes W, Mielke U, Schmidt HJ et al. Acute multifocal placoid pigment epitheliopathy with inflammatory CSF findings. A special form of borreliosis? Dtsch Med Wochenschr 1989; 114: 793-95.
48. Bialasiewicz AA, Huk W, Druschky KF et al. Bilateral optic neuritis with intracranial demyelination in a patient with *Borrelia burgdorferi* infection. Klin Mbl Augenheilk 1989; 195: 91-94.
49. Lesser RL, Kornmehl EW, Pachner AR et al. Neuro-ophthalmologic manifestations of Lyme disease. Ophthalmology 1990; 97: 699-706.
50. Jacobson DM, Marx JJ, Dlesk A. Frequency and clinical significance of Lyme seropositivity in patients with isolated optic neuritis. Am J Ophthalmol 1989; 107: 81.
51. MacDonald AB. Lyme disease, a neuro-ophthalmic view. J Clin Neuro Ophthalmol 1987; 7: 185-90.
52. Pizzarello LD, MacDonald AB, Semlear R et al. Temporal arteritis associated with *Borrelia* infection. J Clin Neuro Ophthalmol 1989; 9: 3-6.
53. Schechter SL. Lyme disease associated with optic neuropathy. Am J Med 1986; 81: 143-45.
54. Stiernstedt G, Gustaffson R, Karlsson M et al. Clinical manifestations and diagnosis of neuroborreliosis. Ann NY Acad Sci 1988; 539: 45-56.
55. Bertuch AW, Rocco E, Schwartz EG. Eye findings in Lyme disease. Conn Medicine 1987; 51: 151-52.
56. Belman AL, Iyer M, Coyle PK et al. Neurologic manifestations in children with North American Lyme disease. Neurology 1993; 43: 2609-14.
57. Jacobson DM, Frens DB. Pseudotumor cerebri syndrome associated with Lyme disease. Neurology 1991; 41: 706-11.
58. Raucher HS, Kauffmann DM, Goldfarb J et al. Pseudotumor cerebri and Lyme disease: a new solution. J Pediatr 1985; 107: 931-33.
59. Schönherr U, Lang GE, Meythaler FH. Bilateral Leber's neuroretinitis stellata with *Borrelia burgdorferi* seroconversion. Klin Mbl Augenheilk 1991; 198: 44-47.
60. Gass JDM. Diseases of the optic nerve that may simulate macular disease. Trans Am Acad Ophthalmol Otolaryngol 1977; 83: 763.
61. Bingham PM, Galetta SL, Athreya B et al. Neurologic manifestations in children with Lyme disease. Pediatrics 1995; 96: 1053-56.
62. Smith JL, Crumpton BC, Hummer J. The Bascom Palmer eye institute Lyme / Syphilis survey. J Clin Neuro Ophthalmol 1990; 10: 255-60.
63. Kehl F, Aust W. Ocular findings in tick borreliosis. Klin Mbl Augenheilk 1988; 193: 66-68.
64. Clark JR, Carlson RD, Sasaki CT et al. Facial paralysis in Lyme disease. Laryngoscope 1985; 95: 1341-45.

65. Barza M, Hooper DC. Fever and facial diplegia in a 21 year-old man. *N Engl J Med* 1984; 331: 172-81.
66. Langmann A, Pizzera B, Millner M. Strabismus paralyticus in neuroborreliosis of childhood. *Spectrum Augenheilkd* 1992; 6: 169-71.
67. Stiernstedt G, Skoldenberg B, Garde A et al. Clinical manifestations of *Borrelia* infections of the nervous system. *Zbl Bakt Hyg* 1986; 263: 289-96.
68. Glauser TA, Brennan PJ, Galetta SL. Reversible Horner's syndrome and Lyme disease. *J Clin Neuro Ophthalmol* 1989; 9: 225-28.
69. Flach AJ, Lavoie PE. Episcleritis, conjunctivitis and keratitis as ocular manifestations of Lyme disease. *Ophthalmology* 1990; 97: 973-75.
70. Fox GM, Heilskov T, Smith JL. Cogan's syndrome and seroreactivity to Lyme Borreliosis. *J Clin Neuro Ophthalmol* 1990; 10: 83-87.
71. Zaidman GW. Episcleritis and symblepharon associated with Lyme keratitis. *Am J Ophthalmol* 1990; 109: 487-88.
72. Clinch TE, Palmon FE, Robinson MJ et al. Microbial keratitis in children. *Am J Ophthalmol* 1994; 117: 65-71.
73. Szer IS, Taylor E, Steere AC. The long term course of Lyme arthritis in children. *N Engl J Med* 1991; 325: 159-63.
74. Baum J, Barza M, Weinstein P et al. Bilateral keratitis as a manifestation of Lyme disease. *Am J Ophthalmol* 1988; 105: 75-77.
75. Kornmehl EW, Lesser RL, Jaros P et al. Bilateral keratitis in Lyme disease. *Ophthalmology* 1989; 96: 1194-97.
76. Orlin SE, Lauffer JL. Lyme disease keratitis. *Am J Ophthalmol* 1989; 107: 678-80.
77. Bertuch AW, Rocco E, Schwartz EG. Lyme disease: Ocular manifestations. *Ann Ophthalmol* 1988; 20: 376-78.
78. de Luise VP, O'Leary MJ. Peripheral ulcerative keratitis related to Lyme disease. *Am J Ophthalmol* 1991; 111: 244-45.
79. Seidenberg KB, Leib ML. Orbital myositis with Lyme disease. *Am J Ophthalmol* 1990; 109: 13-16.
80. Riikonen R, Santavuori P. Hereditary and acquired risk factors for childhood stroke. *Neuropediatrics* 1994; 25: 227-33.
81. MacDonald AB. Ambiguous serologies in active Lyme Borreliosis. *J Clin Neuro Ophthalmol* 1988; 8: 79-80.

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