

Table 6. List of Excluded Studies and Reason for Exclusion

Study	Reasons for exclusion*
Abbouda et al, 2017 ¹	No available individual-level data
Alabduljalil et al, 2015 ²	Conference abstract
Aleman et al, 2017 ³	RPE area not assessed by FAF
Aleman et al, 2018 ⁴	Conference abstract
Al-Qahtani et al, 2018 ⁵	No necessary data
Bains et al, 2003 ⁶	Conference abstract
Batmanabane et al, 2017 ⁷	Conference abstract
Birtel et al, 2019 ⁸	Overlapping dataset
Camino et al, 2018 ⁹	No necessary data
Chung et al, 2014 ¹⁰	Conference abstract
Cideciyan et al, 2015 ¹¹	No necessary data
Colucci et al, 2016 ¹²	Conference abstract
Coussa et al, 2012 ¹³	Overlapping dataset
Cunningham et al, 2018 ¹⁴	Conference abstract
Di Iorio et al, 2019 ¹⁵	No necessary data
Dimopoulos et al, 2015 ¹⁶	Conference abstract
Dimopoulos et al, 2016 ¹⁷	Overlapping dataset
Dimopoulos et al, 2017 ¹⁸	Conference abstract
Duncan et al, 2002 ¹⁹	No necessary data
Edwards et al, 2016 ²⁰	Conference abstract
Esposito et al, 2011 ²¹	Overlapping dataset
Forsius et al, 1977 ²²	No necessary data
Freund et al, 2013 ²³	Conference abstract
Freund et al, 2016 ²⁴	No necessary data
Fry et al, 2018 ²⁵	Conference abstract
Fujiki et al, 1999 ²⁶	No necessary data
Genead et al, 2011 ²⁷	Overlapping dataset
Genead et al, 2011 ²⁸	Conference abstract
Genead et al, 2011 ²⁹	No necessary data
Gochi et al, 2017 ³⁰	Conference abstract
Groppe et al, 2013 ³¹	Conference abstract
Grover et al, 1998 ³²	Overlapping dataset
Halioua-Haubold et al, 2019 ³³	Overlapping dataset
Han et al, 2017 ³⁴	Overlapping dataset
Han et al, 2018 ³⁵	Overlapping dataset
Han et al, 2018 ³⁶	No necessary data
Hariri et al, 2017 ³⁷	No necessary data
Hariri et al, 2018 ³⁸	Conference abstract
Hariri et al, 2019 ³⁹	No necessary data
Hayakawa et al, 1999 ⁴⁰	No necessary data
Heon et al, 2016 ⁴¹	No necessary data
Hirakawa et al, 1999 ⁴²	Less than 5 patients
Jolly et al, 2015 ⁴³	Overlapping dataset
Jolly et al, 2016 ⁴⁴	Conference abstract
Jolly et al, 2017 ⁴⁵	No necessary data
Karna et al, 1986 ⁴⁶	No necessary data
Katz et al, 2006 ⁴⁷	Less than 5 patients
Khan et al, 2016 ⁴⁸	No necessary data
Kurstjens et al, 1965 ⁴⁹	No necessary data
Lam et al, 2017 ⁵⁰	Conference abstract
Lam et al, 2018 ⁵¹	Conference abstract
Lam et al, 2019 ⁵²	No necessary data
Lazow et al, 2011 ⁵³	Conference abstract
Lazow et al, 2011 ⁵⁴	No necessary data
Li et al, 2014 ⁵⁵	No necessary data
MacDonald et al, 1996 ⁵⁶	Conference abstract
MacDonald et al, 2016 ⁵⁷	Conference abstract

MacLaren et al, 2014 ⁵⁸	Conference abstract
MacLaren et al, 2014 ⁵⁹	Overlapping dataset
MacLaren et al, 2016 ⁶⁰	Conference abstract
MacLaren et al, 2018 ⁶¹	Conference abstract
Moosajee et al, 2014 ⁶²	Conference abstract
Morgan et al, 2014 ⁶³	No necessary data
Morgan et al, 2018 ⁶⁴	Conference abstract
Murro et al, 2019 ⁶⁵	Overlapping dataset
Mysore et al, 2013 ⁶⁶	Conference abstract
Patrício et al, 2017 ⁶⁷	Conference abstract
Penesi et al, 2018 ⁶⁸	Conference abstract
Pichi et al, 2013 ⁶⁹	Overlapping dataset
Prokofyeva et al, 2009 ⁷⁰	No necessary data
Prokofyeva et al, 2010 ⁷¹	Conference abstract
Renner et al, 2006 ⁷²	No necessary data
Roberts et al, 2002 ⁷³	No necessary data
Salvetti et al, 2017 ⁷⁴	Conference abstract
Sandberg et al, 2006 ⁷⁵	No necessary data
Seitz et al, 2018 ⁷⁶	Overlapping dataset
Simunovic et al, 2016 ⁷⁷	Overlapping dataset
Simunovic et al, 2017 ⁷⁸	Overlapping dataset
Skorczyk-Werner et al, 2018 ⁷⁹	No necessary data
Spandau et al, 2002 ⁸⁰	Less than 5 patients
Sun et al, 2016 ⁸¹	No necessary data
Traband et al, 2016 ⁸²	Conference abstract
Tuten et al, 2019 ⁸³	Overlapping dataset
van Schuppen et al, 2018 ⁸⁴	No necessary data
Wang et al, 2018 ⁸⁵	No necessary data
Wilson et al, 2018 ⁸⁶	Conference abstract
Xue et al, 2016 ⁸⁷	Overlapping dataset
Xue et al, 2016 ⁸⁸	Conference abstract
Yeoh et al, 2010 ⁸⁹	Less than 5 patients
Zeitz et al, 2016 ⁹⁰	Conference abstract
Zhao et al, 2002 ⁹¹	Conference abstract
Zinkernagel et al, 2013 ⁹²	Less than 5 patients

FAF = fundus autofluorescence; RPE = retinal pigment epithelium.

* "No necessary data" represents studies did not report necessary data for the present meta-analysis, including the area of residual retinal pigment epithelium measured by fundus autofluorescence, and the ages of individual patients.

References:

1. Abbouda A, Lim WS, Sprogyte L, et al. Quantitative and qualitative features of spectral-domain optical coherence tomography provide prognostic indicators for visual acuity in patients with choroideremia. *Ophthalmic Surg Lasers Imaging Retina* 2017;48(9):711-6.
2. Alabduljalil T, Araya MPP, Trang H, et al. Phenotypic characteristics and natural history of choroideremia. *2015;56 (7):3838.*
3. Aleman TS, Han G, Serrano LW, et al. Natural history of the central structural abnormalities in choroideremia: A prospective cross-sectional study. *Ophthalmology* 2017;124(3):359-73.
4. Aleman TS, Silson EH, Willett A, et al. Fmri derived visual field measures correlate highly with clinical perimetry assessments in choroideremia patients. *Mol Ther* 2018;26(5):415-.
5. Al-Qahtani AA, Ba-Ali S, Alabduljalil T, et al. Scleral pits in choroideremia: Implications for retinal gene therapy. *Retina* 2018;38(9):1725-30.
6. Bains HS, Jampol LM. Characterization of posterior pole chorioretinal features using optical coherence tomography in patients with diffuse and focal chorioretinal atrophy. *Invest Ophthalmol Vis Sci* 2003;44:U680-U.

7. Batmanabane V, Vincent A, Heon E. Retinal sensitivity and fixation stability as surrogate markers of visual function in molecularly confirmed choroideremia patients. *Invest Ophthalmol Vis Sci* 2017;58(8).
8. Birtel J, Salvetti AP, Jolly JK, et al. Near-infrared autofluorescence in choroideremia: Anatomic and functional correlations. *Am J Ophthalmol* 2019;199:19-27.
9. Camino A, Wang Z, Wang J, et al. Deep learning for the segmentation of preserved photoreceptors on en face optical coherence tomography in two inherited retinal diseases. *Biomed Opt Express* 2018;9(7):3092-105.
10. Chung DC, Morgan JIW, Charlson ES, et al. Structural findings in carriers and affected individuals with choroideremia - an optical coherence tomography study. *Invest Ophthalmol Vis Sci* 2014;55(13):3383.
11. Cideciyan AV, Swider M, Jacobson SG. Autofluorescence imaging with near-infrared excitation:Normalization by reflectance to reduce signal from choroidal fluorophores. *Invest Ophthalmol Vis Sci* 2015;56(5):3393-406.
12. Colucci R, Boccia R, Di Iorio V, et al. Clinical presentation and disease course in choroideremia patients. *Invest Ophthalmol Vis Sci* 2016;57(12):159.
13. Coussa RG, Kim J, Traboulsi EI. Choroideremia: Effect of age on visual acuity in patients and female carriers. *Ophthalmic Genet* 2012;33(2):66-73.
14. Cunningham C, Daggett H, Stone E, Han I. Scleral pits are a sign of disease severity in choroideremia. *Invest Ophthalmol Vis Sci* 2018;59(9):6059.
15. Di Iorio V, Esposito G, De Falco F, et al. Chm/rep1 transcript expression and loss of visual function in patients affected by choroideremia. *Invest Ophthalmol Vis Sci* 2019;60(5):1547-55.
16. Dimopoulos I, MacDonald IM. Mesopic and scotopic threshold sensitivity in patients with choroideremia: Relationship with residual fundus autofluorescence area. *Invest Ophthalmol Vis Sci* 2015;56(7):2223.
17. Dimopoulos IS, Tseng C, MacDonald IM. Microperimetry as an outcome measure in choroideremia trials: Reproducibility and beyond. *Invest Ophthalmol Vis Sci* 2016;57(10):4151-61.
18. Dimopoulos IS, Knowles J, Sajed T, MacDonald IM. Fundus autofluorescence analysis of the transition zone in choroideremia: Outcomes following gene therapy. *Invest Ophthalmol Vis Sci* 2017;58(8).
19. Duncan JL, Aleman TS, Gardner LM, et al. Macular pigment and lutein supplementation in choroideremia. *Exp Eye Res* 2002;74(3):371-81.
20. Edwards T, Jolly J, Groppe M, et al. 2. Sustained improvement in visual acuity after retinal gene therapy for choroideremia. 2016;44 (Supplement 1):22.
21. Esposito G, De Falco F, Tinto N, et al. Comprehensive mutation analysis (20 families) of the choroideremia gene reveals a missense variant that prevents the binding of rep1 with rab geranylgeranyl transferase. *Hum Mutat* 2011;32(12):1460-9.
22. Forsius H, Hyvarinen L, Nieminen H, Flower R. Fluorescein and indocyanine green fluorescence angiography in study of affected males and in female carriers with choroideremia. A preliminary report. *Acta Ophthalmol (Copenh)* 1977;55(3):459-70.
23. Freund P, Furgoch M, MacDonald I. Genotype-phenotype analysis of male subjects affected by choroideremia. *Invest Ophthalmol Vis Sci* 2013;54(15):1567.
24. Freund PR, Sergeev YV, MacDonald IM. Analysis of a large choroideremia dataset does not suggest a preference for inclusion of certain genotypes in future trials of gene therapy. *Mol Genet Genomic Med* 2016;4(3):344-58.
25. Fry L, Patricio MI, Williams J, et al. Pathological donor splice site mutations beyond the dinucleotide canonical sequence in choroideremia. 2018;59(9):3493.
26. Fujiki K, Hotta Y, Hayakawa M, et al. Rep-1 gene mutations in Japanese patients with choroideremia. *Graefes Arch Clin Exp Ophthalmol* 1999;237(9):735-40.
27. Genead MA, McAnany JJ, Fishman GA. Retinal nerve fiber thickness measurements in choroideremia patients with spectral-domain optical coherence tomography. *Ophthalmic Genet* 2011;32(2):101-6.
28. Genead MA, Fishman GA. Presence and treatment of cystoid macular edema in patients with choroideremia. 2011;2011:2130.
29. Genead MA, Fishman GA. Cystic macular oedema on spectral-domain optical coherence tomography in choroideremia patients without cystic changes on fundus examination. 2011;25(1):84-90.
30. Gocho K, Akeo K, Kubota D, et al. High resolution imaging analysis of female carriers and patients of choroideremia with chm gene mutation. *Invest Ophthalmol Vis Sci* 2017;58(8).
31. Groppe M, Cottriall C, Downes S, McLaren R. Correlation of retinal sensitivity with the area of normal auto-fluorescence in choroideremia patients. *Invest Ophthalmol Vis Sci* 2013;54(15):642.

32. Grover S, Alexander KR, Choi DM, Fishman GA. Intraocular light scatter in patients with choroideremia. *Ophthalmology* 1998;105(9):1641-5.
33. Halioua-Haubold CL, Jolly JK, Smith JA, et al. Potential lifetime quality of life benefits of choroideremia gene therapy: Projections from a clinically informed decision model. *Eye (Lond)* 2019.
34. Han RC, Jolly JK, Xue K, MacLaren RE. Effects of pupil dilation on maia microperimetry. *Clin Exp Ophthalmol* 2017;45(5):489-95.
35. Han RC, Gray JM, Han J, et al. Optimisation of dark adaptation time required for mesopic microperimetry. *Br J Ophthalmol* 2018;29:29.
36. Han X, Li H, Wu S, et al. Study of natural history of chinese patients with choroideremia. [chinese]. *2018;36(7):519-25.*
37. Hariri AH, Velaga SB, Girach A, et al. Measurement and reproducibility of preserved ellipsoid zone area and preserved retinal pigment epithelium area in eyes with choroideremia. *Am J Ophthalmol* 2017;179:110-7.
38. Hariri AH, Girach A, Ip MS, et al. Spatial distribution of preserved autofluorescence in patients with choroideremia. *2018;59(9):4991.*
39. Hariri AH, Ip MS, Girach A, et al. Macular spatial distribution of preserved autofluorescence in patients with choroideremia. *Br J Ophthalmol* 2019;103(7):933-7.
40. Hayakawa M, Fujiki K, Hotta Y, et al. Visual impairment and rep-1 gene mutations in japanese choroideremia patients. *Ophthalmic Genet* 1999;20(2):107-15.
41. Heon E, Alabduljalil T, McGuigan ID, et al. Visual function and central retinal structure in choroideremia. *Invest Ophthalmol Vis Sci* 2016;57(9):OCT377-87.
42. Hirakawa H, Iijima H, Gohdo T, et al. Progression of defects in the central 10-degree visual field of patients with retinitis pigmentosa and choroideremia. *Am J Ophthalmol* 1999;127(4):436-42.
43. Jolly JK, Groppe M, Birks J, et al. Functional defects in color vision in patients with choroideremia. *Am J Ophthalmol* 2015;160(4):822-31 e3.
44. Jolly JK, Cottriall CL, Groppe M, MacLaren RE. Characterisation of scotopic vision in patients with choroideremia utilising full-field stimulus threshold (fst). *Invest Ophthalmol Vis Sci* 2016;57(12):621.
45. Jolly JK, Xue K, Edwards TL, et al. Characterizing the natural history of visual function in choroideremia using microperimetry and multimodal retinal imaging. *Invest Ophthalmol Vis Sci* 2017;58(12):5575-83.
46. Karna J. Choroideremia. A clinical and genetic study of 84 finnish patients and 126 female carriers. *Acta Ophthalmol Suppl* 1986;176:1-68.
47. Katz BJ, Yang Z, Payne M, et al. Fundus appearance of choroideremia using optical coherence tomography. *Adv Exp Med Biol* 2006;572:57-61.
48. Khan KN, Islam F, Moore AT, Michaelides M. Clinical and genetic features of choroideremia in childhood. *Ophthalmology* 2016;123(10):2158-65.
49. Kurstjens JH. Choroideremia and gyrate atrophy of the choroid and retina. *Doc Ophthalmol* 1965;19(1):2-122.
50. Lam BL, Verriotto J, Gregori N, Davis JL. Choroideremia gene therapy phase ii clinical trial: 6-month results. *Invest Ophthalmol Vis Sci* 2017;58(8).
51. Lam BL, Fischer MD, Pennesi ME, et al. Natural history of progression of choroideremia (night) study: Cross-sectional analysis of baseline characteristics. *2018;59(9):3899.*
52. Lam BL, Davis JL, Gregori NZ, et al. Choroideremia gene therapy phase 2 clinical trial: 24-month results. *2019;197:65-73.*
53. Lazow MA, Hood DC, Birch DG. Fdoct analysis of the transition zone between healthy and severely affected regions in patients with choroideremia. *2011;2011:4976.*
54. Lazow MA, Hood DC, Ramachandran R, et al. Transition zones between healthy and diseased retina in choroideremia (chm) and stargardt disease (stgd) as compared to retinitis pigmentosa (rp). *Invest Ophthalmol Vis Sci* 2011;52(13):9581-90.
55. Li S, Guan L, Fang S, et al. Exome sequencing reveals chm mutations in six families with atypical choroideremia initially diagnosed as retinitis pigmentosa. *2014;34(2):573-7.*
56. MacDonald IM, Chen M, Mitchell G, et al. Mutation analysis of canadian families with choroideremia. *Invest Ophthalmol Vis Sci* 1996;37(3):5237-.
57. MacDonald IM, Dimopoulos I, Chan S, et al. Ocular gene therapy for choroideremia: The alberta experience. *Invest Ophthalmol Vis Sci* 2016;57(12).

58. MacLaren RE, Groppe M, Barnard AR, et al. Improved visual function in patients with choroideremia undergoing subretinal gene therapy. 2014;55 (13):832.
59. MacLaren RE, Groppe M, Barnard AR, et al. Retinal gene therapy in patients with choroideremia: Initial findings from a phase 1/2 clinical trial. Lancet 2014;383(9923):1129-37.
60. MacLaren RE, Edwards TL, Jolly J, et al. Long term vision results following retinal gene therapy for choroideremia. 2016;57(12).
61. MacLaren RE, Xue KM, Barnard AR, et al. Retinal gene therapy for choroideremia in a multicenter dose escalation phase i/ii clinical trial. Invest Ophthalmol Vis Sci 2018;59(9).
62. Moosajee M, Ramsden SC, Black GC, et al. Spectrum of chm mutations, structural retinal features and their progression in choroideremia patients within the uk. Invest Ophthalmol Vis Sci 2014;55(13):2136.
63. Morgan JI, Han G, Klinman E, et al. High-resolution adaptive optics retinal imaging of cellular structure in choroideremia. Invest Ophthalmol Vis Sci 2014;55(10):6381-97.
64. Morgan JIW, Tuten WS, Cooper RF, et al. Cellular-scale assessment of visual function in choroideremia. Invest Ophthalmol Vis Sci 2018;59(9):1151.
65. Murro V, Mucciolo DP, Giorgio D, et al. Optical coherence tomography angiography (oct-a) in young choroideremia (chm) patients. 2019;40(3):201-6.
66. Mysore N, Cao S, Koenekoop J, et al. Choroideremia is a systemic disease with retinal crystals, lymphocyte crystals and serum lipid abnormalities. 2013;54(15):716.
67. Patricio MI, Barnard AR, Orlans HO, et al. Inclusion of the woodchuck hepatitis virus posttranscriptional regulatory element enhances aav2-driven transduction of mouse and human retina. Mol Ther Nucleic Acids 2017;6:198-208.
68. Pennesi ME, Lam BL, Fischer MD, et al. The natural history of the progression of choroideremia (night) study: Longitudinal changes in visual acuity over 12 months. 2018;59(9):3898.
69. Pichi F, Morara M, Veronese C, et al. Multimodal imaging in hereditary retinal diseases. J Ophthalmol 2013;2013:634351.
70. Prokofyeva E, Wilke R, Lotz G, et al. An epidemiological approach for the estimation of disease onset in central europe in central and peripheral monogenic retinal dystrophies. Graefes Arch Clin Exp Ophthalmol 2009;247(7):885-94.
71. Prokofyeva E, Troeger E, Wilke R, Zrenner E. Age of visual symptoms onset in different types of inherited retinal degenerations. 2010;51(13):3548.
72. Renner AB, Kellner U, Cropp E, et al. Choroideremia: Variability of clinical and electrophysiological characteristics and first report of a negative electroretinogram. 2006;113(11):2066-73.
73. Roberts MF, Fishman GA, Roberts DK, et al. Retrospective, longitudinal, and cross sectional study of visual acuity impairment in choroideraemia. Br J Ophthalmol 2002;86(6):658-62.
74. Salvetti AP, Birtel J, Xue K, et al. Near-infrared autofluorescence in choroideremia: Anatomical and functional correlations. 2017;58(8).
75. Sandberg MA, Gaudio AR. Reading speed of patients with advanced retinitis pigmentosa or choroideremia. Retina 2006;26(1):80-8.
76. Seitz IP, Jolly JK, Dominik Fischer M, Simunovic MP. Colour discrimination ellipses in choroideremia. Graefes Arch Clin Exp Ophthalmol 2018;256(4):665-73.
77. Simunovic MP, Jolly JK, Xue K, et al. The spectrum of chm gene mutations in choroideremia and their relationship to clinical phenotype. Invest Ophthalmol Vis Sci 2016;57(14):6033-9.
78. Simunovic MP, Xue K, Jolly JK, MacLaren RE. Structural and functional recovery following limited iatrogenic macular detachment for retinal gene therapy. JAMA Ophthalmol 2017;135(3):234-41.
79. Skorczyk-Werner A, Wawrocka A, Kochalska N, Krawczynski MR. Novel chm mutations in polish patients with choroideremia - an orphan disease with close perspective of treatment. Orphanet J Rare Dis 2018;13(1):221.
80. Spandau UH, Wechsler S, Blankenagel A. Testing night vision goggles in a dark outside environment. Optom Vis Sci 2002;79(1):39-45.
81. Sun LW, Johnson RD, Williams V, et al. Multimodal imaging of photoreceptor structure in choroideremia. PLoS One 2016;11(12):e0167526.
82. Traband A, Fuerst N, Serrano L, et al. Natural history of the central structural abnormalities in choroideremia: Insights from a cross-sectional study. 2016;57(12):6587.
83. Tuten WS, Vergilio GK, Young GJ, et al. Visual function at the atrophic border in choroideremia assessed with adaptive optics microperimetry. 2019;08:08.

84. van Schuppen SM, Talib M, Bergen AA, et al. Long-term follow-up of patients with choroideremia with scleral pits and tunnels as a novel observation. *Retina* 2018;38(9):1713-24.
85. Wang Z, Camino A, Hagag AM, et al. Automated detection of preserved photoreceptor on optical coherence tomography in choroideremia based on machine learning. *J Biophotonics* 2018;11(5):e201700313.
86. Wilson IR, Jolly J, Downes S, MacLaren RE. Beyond the average threshold: Alternatives in the analysis of microperimetry data. 2018;59(9):1698.
87. Xue K, Oldani M, Jolly JK, et al. Correlation of optical coherence tomography and autofluorescence in the outer retina and choroid of patients with choroideremia. *Invest Ophthalmol Vis Sci* 2016;57(8):3674-84.
88. Xue K, Oldani M, Jolly J, et al. Rpe degeneration precedes photoreceptor and choroidal loss in choroideremia based on enhanced-depth oct and fundus autofluorescence correlations. 2016;57(12).
89. Yeoh J, Rahman W, Chen F, et al. Choroidal imaging in inherited retinal disease using the technique of enhanced depth imaging optical coherence tomography. 2010;248(12):1719-28.
90. Zeitz C, Kloeckener-Gruissem B, Lancelot M-E, et al. A comprehensive molecular analysis of patients with the diagnosis of choroideremia. 2016;57(12):661.
91. Zhao D, Wintch SW, Gellermann W, Bernstein PS. Resonance raman spectroscopic measurement of macular carotenoid pigments in patients with choroidal and retinal dystrophies. 2002;2002:2544.
92. Zinkernagel MS, Groppe M, MacLaren RE. Macular hole surgery in patients with end-stage choroideremia. *Ophthalmology* 2013;120(8):1592-6.