

Cost-Effectiveness of Limited Vitrectomy for Vision-Degrading Myodesopsia



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• **PURPOSE:** Patients afflicted with clinically significant vitreous floaters suffer from vision-degrading myodesopsia, characterized by impairment in contrast sensitivity function (CSF) and decreased quality of life. This study determined the cost-effectiveness of limited vitrectomy for this condition.

• **DESIGN:** Retrospective, interventional case series and third-party insurer cost-utility analysis.

• **METHODS:** Sixty-seven patients suffering from unilateral vitreous floaters (20 non-myopic patients with posterior vitreous detachment [PVD]; 17 myopic patients [> -2 diopters] without PVD; 30 myopic patients with PVD) completed the National Eye Institute Visual Function Questionnaire (VFQ-39) and were tested with best-corrected visual acuity (BCVA) and CSF measurements before and after limited vitrectomy. A reference case cost-utility analysis was performed.

• **RESULTS:** The mean VFQ-39 increased 19% ($P < 0.00001$) after surgery, with general vision improving 27% for the entire group and 37% for non-myopic PVD ($P < 0.00001$ for each). VFQ-39 correlations with time tradeoff utilities indicated a 14.4% improvement in quality of life. Mean BCVA improved 13.5% postoperatively ($P < 0.00001$) and CSF improved 53% ($P < 0.00001$). The incremental patient value gain conferred by limited vitrectomy was 2.38 quality-adjusted life-years (QALYs), and the average cost-utility ratio in 2018 U.S. real dollars was \$1,574/QALY.

• **CONCLUSIONS:** Limited vitrectomy for vision-degrading myodesopsia is clinically effective, in that it improves BCVA, CSF, and patient well-being. It is also highly cost-effective (\$1,574/QALY), with an average cost-utility ratio vs. no therapy that is superior to cataract surgery (\$2,262/QALY), amblyopia therapy (\$2,710/QALY), and retinal detachment repair (\$45,304/QALY). Myopic patients without PVD had the lowest

cost-utility ratio of all (\$1,338/QALY). (Am J Ophthalmol 2019;204:1–6. © 2019 Elsevier Inc. All rights reserved.)

VITREOUS FLOATERS ARE A COMMON CONDITION, producing symptoms in far more people than is generally appreciated. A 2002 survey in the United Kingdom revealed an average of 14 patients per month per optometrist presented with concerns referable to vitreous floaters.¹ A recent smartphone survey administered to 603 people found that 76% of individuals reported seeing floaters, and 33% reported vision impairment because of their floaters.² While this cannot be directly extrapolated to the general population because of selection biases including the young demographics of smartphone users, this is still an alarming statistic. Fortunately, the majority of vitreous floaters do not impact vision enough to be very bothersome and most people manage to cope with this visual phenomenon. However, in many cases there is sufficient disturbance to negatively impact quality of life.^{3–5}

Studies have determined that in bothersome cases there is profound degradation in contrast sensitivity function (CSF),^{6,7} qualifying the condition as a disease that can be referred to as *vision-degrading myodesopsia*, so as to distinguish such cases from vitreous floaters that are not clinically significant. Ultrasound studies have identified structural correlates of these functional deficits,⁸ providing yet another way to characterize severity and distinguish between mild, moderate, and severe cases.

Subjective assessment of visual well-being through cross-sectional questionnaire studies has demonstrated that bothersome vitreous floaters have a negative impact on patient quality of life—so much so, that patients are willing to trade off an average of 1.1 years out of every 10 years of remaining life to get rid of their floater symptoms,⁴ a finding confirmed by other studies.³ Indeed, the negative impact is so great that the utility values for clinically significant floaters have been cited to be lower (meaning a more severely negative impact) than mild angina, mild stroke, colon cancer, and asymptomatic AIDS.^{4,5}

Limited vitrectomy is a definitive solution by which vitreous opacities can be excised and visual function can be normalized. Short-term⁹ and long-term¹⁰ studies have demonstrated a high safety profile and exceptional efficacy, with normalization of visual function. This is accompanied by documented improvement in patient visual well-being,

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as quantified by the National Eye Institute (NEI) Visual Function Questionnaire.⁹⁻¹³

What is lacking, however, is an analysis of the cost-effectiveness of this treatment. Since various ophthalmic drug regimens and surgical procedures have previously been analyzed using cost-utility analysis,^{14,15} this study was designed to answer the question of whether limited vitrectomy is a cost-effective treatment for vision-degrading myodesopsia.

METHODS

THIS STUDY ADHERED TO THE TENETS OF THE HELSINKI accord governing human research and was approved by the institutional review board of St. Joseph Hospital, Orange, California, USA. All subjects signed an approved consent form prior to any testing, which was performed prospectively before and after surgery, but all analyses were performed retrospectively.

- **INCLUSION CRITERIA:** All patients presented with the chief complaint of markedly bothersome unilateral floaters and had abnormal findings on the NEI Visual Function Questionnaire (VFQ-39) testing, degradation in contrast sensitivity function (worse than 2.6% Weber), and increased echodensity on ultrasonography (see below for testing protocol details).

- **EXCLUSION CRITERIA:** Patients were excluded if there was a history of prior vitreoretinal surgery, diabetic retinopathy, age-related macular degeneration, visually significant cataract, or any other condition that could impact vision.

- **STUDY POPULATION:** There were 67 qualifying patients: 49 (73%) men and 18 (27%) women. The mean age was 52 years (standard deviation \pm 15 years) and the mean life expectancy was 31 years.¹⁶

Ultrasonography (AVISIO; Biophysic Medical, Clermont-Ferand, France) was used to diagnose posterior vitreous detachment (PVD), confirmed by optical coherence tomography (OCT; Optos, Marlborough, Massachusetts, USA) when the posterior vitreous cortex was close enough to the retina to be visualized. There were 20 nonmyopic patients with PVD; 17 myopic patients ($>$ -2 diopters [D]; mean = -6.0 D, SD \pm 3.4) without PVD; and 30 myopic patients (mean = -5.7 D, SD \pm 3.9) with PVD.

All subjects completed the NEI VFQ-39 and underwent baseline best-corrected visual acuity (Snellen decimal; BCVA) and CSF testing using the Freiburg Acuity Contrast Test (FrACT) prior to surgery, as previously described.⁶⁻¹⁰ FrACT¹⁷⁻¹⁹ is a computerized test that uses a light-emitting diode computer display with a resolution of 218 pixels per square inch to display a tumbling gapped

Landolt C at different contrast levels in 1 of 8 possible orientations. Luminance calibration is performed before each test by manually inputting measurements, including the patient's distance from the monitor and the length of a ruler line on the display. The program then calculates the screen resolution and visual angle of the optotypes. The same display monitor was used throughout the study. Testing was done at the patient's eye level under mesopic conditions in a dark room following 3 minutes of dark adaptation. The Landolt C letter was presented in gray on a lighter background as described above, with a spatial frequency of 5 cycles per degree, and 18 trials per test. All patients were tested with their refractive correction at a distance of 2.9 meters with the fellow eye occluded. A software algorithm computed the patient's CSF, expressing the results as the Weber index (%W), defined as: $W = (L_{max} - L_{min})/L_{max} \times 100$, where L is the luminance, and lower %W values indicate better CSF. CSF measurements obtained at this institute with this test have been previously reported to be 92% reproducible.⁹

Limited 25G vitrectomy (ALCON Surgical, Ft. Worth, Texas, USA) was performed without extensive peripheral vitreous excision, as previously described.^{9,10} In the absence of PVD, surgical PVD was not induced. In phakic eyes, 3-4 mm of retrolental vitreous was left intact. The same diagnostics (VFQ-39, BCVA, FrACT) were performed 1-3 months postoperatively.

A cost-utility analysis was performed using the national average Medicare Fee Schedule, patient time tradeoff utilities correlated with the NEI VFQ-39, and a third-party insurer cost perspective. Time tradeoff utilities were correlated with the NEI VFQ using data from Brown,²⁰ Sheperd and associates,²¹ and Massof and Ahmadian.²²

Costs and patient value (quality-of-life) gain in quality-adjusted life-year (QALY) outcomes were discounted with net present value analysis at 3% per annum over a 31-year horizon, the average life expectancy among the 67 patients. The QALY losses and costs associated with the adverse events encountered following limited vitrectomy were included. The main adverse event was cataract formation requiring surgery in 8 of 67 eyes (11.9%), performed at a mean of 10.75 months after limited vitrectomy. One eye of 67 (1.5%) developed a retinal detachment at 11 months after limited vitrectomy, repaired by a subsequent pars plana vitrectomy with laser. There were no cases of endophthalmitis, macular edema, or glaucoma.

The average QALY loss from adverse events included the weighted adverse events of discomfort (utility = 0.89) and erythema (utility = 0.96) from vitrectomy surgery for retinal detachment and for postvitrectomy cataract surgery.^{14,15} These were short-term events, assumed to last 2 days for cataract surgery and 2 weeks for vitrectomy. Visual loss disutility from these adverse events was not subtracted from the overall QALY gain because it was already integrated into the VFQ-39 results upon which the utility gain from limited vitrectomy was based.

TABLE 1. Study Group Demographics

Subgroup	Total N	M	F	Mean Age (\pm SD),
				Years
Non-myopic patients with PVD	20	13	7	64 (\pm 13)
Myopic patients without PVD	17	14	3	41 (\pm 15)
Myopic patients with PVD	30	22	8	58 (\pm 9)

PVD = posterior vitreous detachment.

Immediate discomfort and erythema from limited vitrectomy were also assumed to be integrated into the VFQ-39 results.

Cost-effectiveness (cost utility) was determined for the entire group ($n = 67$), as well as for the subgroups of myopic patients with PVD ($n = 30$, mean age = 58 years), myopic patients without PVD ($n = 17$, mean age = 41 years), and non-myopic patients with PVD ($n = 20$, mean age = 64 years).

RESULTS

TABLE 1 PRESENTS THE DEMOGRAPHICS OF THE STUDY POPULATION. Pre- and post-operative findings for VFQ-39, BCVA, and CSF testing in the entire study group are shown in **Table 2**. Post-operatively, the average VFQ-39 score for the entire group increased from 76.35 (out of 100) to 90.75, representing an 18.9% improvement ($P < 0.00001$). The “general vision” subsection in this questionnaire improved by 27% for the entire group ($P < 0.00001$), but in the non-myopic with PVD cohort improvement was 36.7% ($P < 0.00001$). BCVA improved from 0.72 to 0.82, representing a 13.5% improvement ($P < 0.00001$). CSF improved from 4.47 to 2.1 %W (normal range < 2.4 %W), representing a 53% improvement ($P < 0.00001$).

Subgroup analyses comparing non-myopic patients with PVD to myopic patients with PVD and myopic patients without PVD found that VFQ, BCVA, and CSF all improved in each subgroup by a statistically significant amount (**Table 3**). Improvement in BCVA was greatest in myopic patients with PVD (17.2%) and least in myopic patients without PVD (9.7%). CSF and quality-of-life improvements were comparable in each of the 3 subgroups.

• **PATIENT VALUE (QUALITY-ADJUSTED LIFE-YEAR) GAINS:** When the VFQ-39 results were correlated with time tradeoff vision utilities, the mean pre-operative utility was 0.802 and the post-operative utility was 0.918, a 14.4% gain in quality of life. Over 31 years, the total discounted QALY gain was 2.379 QALYs. Integrating the 0.00162 QALY loss associated with the adverse events (cataract surgery, retinal detachment repair) encountered with

TABLE 2. Best-Corrected Visual Acuity and Diagnostic Testing for the Entire Study Group

	Quality-of-Life and Vision Testing Results					
	BCVA (Decimal)		CSF (%Weber)		VFQ-39	
	Preop	Postop	Preop	Postop	Preop	Postop
Mean	0.72	0.82	4.47	2.1	76.35	90.75
SD	0.2	0.17	1.91	1.02	12.91	7.16
% change		13.5%		53.0%		18.9%
P value		< 0.00001		< 0.00001		< 0.00001

BCVA = best-corrected Snellen visual acuity (expressed in decimal); CSF = contrast sensitivity function; Postop = postoperative; Preop = preoperative; VFQ-39 = National Eye Institute Visual Function Questionnaire (39 questions).

TABLE 3. Subgroup Analyses of Quality-of-Life and Vision Testing Results

	BCVA (Decimal)		CSF (% Weber)		VFQ-39	
	Preop	Postop	Preop	Postop	Preop	Postop
Non-myopic patients with PVD ($n = 20$)						
Mean	0.75	0.84	4.7	2.03	77.79	90.85
SD	0.19	0.16	2.2	0.97	13.34	8.82
% change		11.4%		56.9%		16.8%
P value		0.0046		< 0.00001		0.000056
Myopic patients without PVD ($n = 17$)						
Mean	0.73	0.8	3.51	1.75	74.06	89.9
SD	0.22	0.23	0.83	0.42	13.68	8.75
% change		9.7%		49.9%		21.4%
P value		0.037		< 0.00001		< 0.00001
Myopic patients with PVD ($n = 30$)						
Mean	0.7	0.82	4.96	2.34	76.69	91.17
SD	0.19	0.16	1.86	1.23	12.45	16.43
% change		17.2%		52.9%		18.9%
P value		0.000609		< 0.00001		< 0.00001

BCVA = Snellen visual acuity (expressed in decimal); CSF = contrast sensitivity function; PVD = posterior vitreous detachment; Postop = postoperative; Preop = preoperative; VFQ-39 = National Eye Institute Visual Function Questionnaire (39 questions).

limited vitrectomy, the total QALY gain was 2.378, a 14.4% improvement in quality of life.

Table 4 presents the cost-utility analysis data for the group overall, as well as each sub-cohort. The patient value gain integrating adverse events in the nonmyopic patients with PVD cohort was 1.697 QALYs, a 13.2% improvement in quality of life. In the myopic patients without PVD cohort, it was 2.796 QALYs, a 14.6% improvement in quality of life, and in the myopic patients with PVD cohort it was 2.153 QALYs, a 14.5% improvement in quality of life.

TABLE 4. Cost-Utility Analysis of Total Group and Subgroups

Cost-Utility Analysis of Total Group			
Model time frame	31 years		
QALY gained	2.379		
Limited vitrectomy cost	\$3,742 ^a		
Total group cost-utility ratio	\$1,574/QALY		
Cost-Utility Analysis of Subgroups			
	Nonmyopic Patients With PVD	Myopic Patients Without PVD	Myopic Patients With PVD
QALY gained	1.697	2.796	2.153
% change in quality of life	13.2%	14.6%	14.5%
Cost-utility ratio	\$2,204/QALY	\$1,338/QALY	\$1,738/QALY

PVD = posterior vitreous detachment; QALY = quality-adjusted life year.
^aIncludes weighted cost of adverse events.

• **COSTS:** The 2018 ophthalmic direct medical costs (surgeon, anesthesia, ambulatory surgery center, medication) associated with limited pars plana vitrectomy using the national average Medicare Fee Schedule total \$3,378. When the \$364 weighted costs of the adverse events are included, the total cost of limited pars plana vitrectomy is \$3,742.

• **COST-EFFECTIVENESS:** On the basis of the VFQ-39 survey data as a measure of quality of life, as described above, the incremental patient value gain conferred by limited vitrectomy for vision degrading floaters was 2.379 QALYs. With a Medicare Fee Schedule cost of \$3,742, the average cost-utility ratio (CUR) for the procedure vs no therapy for the overall cohort of 67 patients was \$1,574/QALY.

Subgroup analyses showed that for nonmyopic patients with PVD, the average CUR was \$2,204/QALY. For the myopic patients without PVD cohort, the average CUR was \$1,338/QALY, while for the myopic patients with PVD cohort, the average CUR was \$1,738/QALY (Table 4).

• **SENSITIVITY ANALYSIS:** Sensitivity analysis was used to examine uncertainty around individual input values to the model, namely cost and QALY gain, showing that the results were robust to large variations in the model parameters. The upper limit of direct (ophthalmic) medical cost in order for limited vitrectomy to have a CUR of \$100,000/QALY is \$237,774, while for a CUR of \$50,000/QALY it is \$118,887. Clearly, the medical costs of this procedure (\$3,742) are far less than these upper limits. The lower limit of QALY gain in order for limited vitrectomy to

have a CUR of \$100,000/QALY is 0.0374, 1.6% of the QALY gain observed in this study of 2.378, while for a CUR of \$50,000/QALY, it is 0.0748, 3.1% of our QALY gain.

When visual acuity was correlated with utilities in the reference case, the mean vision in the 67 eyes treated with vitrectomy improved from 20/30+1 to 20/25+1. The vision utility associated with 20/20 in 1 eye and 20/30+1 in the fellow eye is 0.92, while improvement to 20/25+1 in the limited vitrectomy eye and 20/20 in the fellow eye is associated with an utility of 0.94.²⁰ This results in a 0.410 QALY gain, a 2.2% improvement in quality of life. The cost-utility ratio using utilities correlated with visual acuity results is \$9,117/QALY.

DISCUSSION

VITREOUS FLOATERS ARE TOLERATED BY MOST PEOPLE, BUT can degrade vision and be extremely bothersome in some cases. Patients experiencing vision degradation may benefit from limited vitrectomy to remove the vitreous opacities. Identifying these patients has been made easier with quantitative ultrasound and by measuring contrast sensitivity function. The former has been found to correlate not only with patient well-being (VFQ assessment), but also with visual function.⁸ CSF was found to decline following PVD but normalized following limited vitrectomy. This surgery has been shown to decrease vitreous echodensity,⁹ improve visual acuity,²³ normalize contrast sensitivity function,^{6,9,10} and improve quality of life.⁹⁻¹³ In addition to demonstrated clinical efficacy, this surgery has now been evaluated from a health-economics perspective using cost-utility analysis.²⁴

The CUR of \$1,574/QALY associated with the limited vitrectomy for vision-degrading myodesopsia indicates the intervention is highly cost-effective, a previously unknown finding. This CUR is dramatically less than the often-cited upper limit of cost-effectiveness of \$100,000/QALY for any medical procedure.¹⁴ Furthermore, this reference case CUR compares favorably with cataract surgery (first eye) whose cost-utility ratio is \$2,262/QALY, amblyopia therapy (CUR = \$2,710/QALY), and retinal detachment repair that can range up to as high as \$45,304/QALY.¹⁵ When the Snellen visual acuity outcomes are used to correlate with utilities, the intervention still remains highly cost-effective at \$9,119/QALY. However, quality of life measured with the NEI VFQ-39 captures more of the patient quality-of-life gain for this procedure than does visual acuity alone. This is probably owing to the marked decrease in CSF in this condition, for which we do not currently have correlated time tradeoff utilities.

Of further interest is the observation that limited vitrectomy is nearly 2 times more cost-effective in myopic

patients without PVD than non-myopic patients with PVD (Table 4). Myopia is an increasingly significant public health problem, with studies showing increased prevalence in the United States from 25% in 1971-72, to 41.6% in 1999-2004 ($P < 0.001$).²⁵ Studies of global trends predict that by 2050 there will be 4.758 billion people with myopia and 938 million people with high myopia.²⁶ Meta-analysis and modeling found that by 2050 global visual impairment from myopia will reach 55.7 million people, 18.5 million of whom will be blind.²⁷ In the context of this study, myopia is known to cause myopic vitreopathy, characterized by precocious vitreous gel liquefaction and intravitreal fiber formation.²⁸ These opacities are a significant cause of unhappiness, as studies have found that myopia is the second-leading cause of vision-degrading myodesopsia.¹⁰ Thus, the finding that of all subgroups, myopic patients without PVD had the most favorable cost-effectiveness of limited vitrectomy is important in providing guidance for case selection. Furthermore, the younger age of myopic patients (mean age = 41 years) than non-myopic patients with PVD (mean age = 64 years) in this study suggests that the benefits of limited vitrectomy will be experienced during a more active and productive period of life and last even longer in myopic patients.

The NEI VFQ-39 reflects the use of both eyes together, yet correlations with utilities reflected the pronounced degree of disability experienced by patients, despite the fact that these cases were unilateral. Furthermore, the VFQ-39 detected a statistically significant improvement post-operatively because the fellow eye was unaffected in each case, and thus marked differences in contrast sensitivity function, psychological overlay, and other factors

may have played a role in the difficulty of using both eyes simultaneously when one eye was afflicted with significant vitreous floaters.

Limitations in this study are the relatively small sample size and short length of follow-up, since adverse events such as retinal detachment and cataract surgery can occur after the follow-up period. However, the results of a larger study ($n = 195$) with longer follow-up (average of 32 months; 24 cases followed for >5 years, 51 for >4 years, and 69 for >3 years) found similar incidences of retinal detachment (1.5%) and cataract surgery (16.9%, compared to 11.9% in the present study). Furthermore, the mean time to cataract surgery after limited vitrectomy was 13 months in the previous study, comparable to 11 months in the present study.

In conclusion, limited vitrectomy for vision-degrading myodesopsia appears to be not only safe and effective from a clinical standpoint,^{6-13,23} but also cost-effective from a health-economics perspective. This needs to be confirmed with larger studies of longer duration in order to capture long-term adverse events as well as be more comparable to previous cost-effectiveness studies of other ophthalmic procedures. Future studies should also use contrast sensitivity function data as an outcome measure that might show even greater cost-effectiveness, as CSF improvement was 3-fold greater than other outcome measures. However, to do this requires establishing utilities associated with different levels of CSF. As a tool that incorporates the impact of many aspects of vision (acuity, color vision, and stereopsis, as well as CSF) the VFQ-39 does account for this, at least in part.

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