REVIEW

Current Perspectives of Bioptic Driving in Low Vision

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ABSTRACT

In this review, the authors discuss the current perspectives of spectacle-mounted telescopes (bioptics) used for driving among patients with vision impairments. The history, design, driving laws surrounding bioptic use, and developing programs in The Netherlands and Canada are discussed. Patients who have certain visual requirements and stable disease status may be eligible candidates to consider using a bioptic aid for driving. Given the high prevalence of depression among visually impaired patients, low vision specialists can work with neuro-ophthalmologists to maximise the independence and visual function of patients who have permanent vision impairments but capable of maintaining driving privileges.

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Introduction

In 2004, it was estimated that there were 4000 to 5000 bioptic drivers in the United States.¹ The percentage of these patients with neuro-ophthalmic disease has never been investigated, but studies report that patients with neuro-ophthalmic disease use bioptics for driving.² Currently, 45 states in the United States allow bioptic driving if patients meet certain requirements. Utah, Iowa, Connecticut, Maine, and Washington, DC, explicitly state that bioptics are not permitted to be used while driving, and Minnesota permits them on a case-by-case basis.³ The visual requirements and guidelines vary from state to state, including the minimum and maximum amount of telescopic magnification allowed. Most US states require that in order to be licensed with full-time privileges, drivers must have a minimum 20/40 visual acuity and 120–140° total visual field.⁴ When a patient's visual status starts to fall below this standard, their eligibility may be threatened and other options need to be considered to maintain privileges.

Bioptic defined

In 1970, Donald Korb was the first to publish a report on the use of bioptics in visually impaired drivers (Table 1).⁵ In 1977, William Feinbloom, OD, PhD, developed new bioptic designs that

became widely accepted and used for low-vision drivers.⁶ The bioptic could be used for spotting objects, people, or signs at a distance for different activities of daily living. The bioptic includes a telescope mounted on top of a standard pair of spectacles or drilled into the upper part of the lenses (Figure 1). The telescopes can be placed in one or both lenses depending on patient goals, ocular dominance, and presenting visual function. Patients with central vision loss should use the telescope for quick spotting at distance and use the carrier lens (most of the time) for ambulating and normal viewing. In this manner, the mounted telescope (above the patient's normal line of sight) would be used as an ancillary tool to magnify distance images periodically, depending on the primary task at hand.

Driving is one of the more important activities of daily living for elderly patients. It is estimated that 13%⁷ to 38%^{8,9} of elderly patients with vision impairments experience depressive symptoms. When faced with driving cessation as a result of vision loss, these patients reported higher levels of depressive symptoms than those who remained drivers.¹⁰ Loss of ability to accomplish basic daily living skills such as driving contribute to their distress. Patients who lose their ability to drive experience social isolation and an overall reduced quality of life.^{10–12} If patients live in a country or state that allows bioptic driving, it is

Table 1. Timeline of key events for bioptic driving in the United States.

Bioptic history	
1925	American Medical Association develops vision standards for driving. ²⁸
1970	First report was published on bioptic driving.
1971	California first state to issue bioptic driver's license.
1977	William Feinbloom released new bioptic designs; New York allows bioptic driving.
1984	Department of Transportation (DOT) endorses bioptic driving.
2001	Bioptic driving allowed in 34 of 50 states.
2006	Demonstration project to investigate bioptic driving in The Netherlands. ²²
2015	Bioptic driving is allowed in 45 of 50 states, but not allowed in Utah, Iowa, Connecticut, Maine, and Washington, DC. Minnesota requires special permission. ³

Figure 1. Magnifying telescopes are mounted in the upper part of standard spectacle lenses right above the pupil at an angle of 10–15° above the line of sight. A patient drops their chin slightly to view through the telescope and may lift their chin to view through their standard glasses correction. Majority of the time the patient is viewing through their spectacle correction (carrier lens) while relying on the telescope to spot detail on signs and check for pedestrians.

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an option for patients with low vision, including those conditions caused by neuro-ophthalmic disease. It allows patients who are motivated to continue driving to maintain their independence and overall quality of life.¹¹

Low vision specialists are trained to properly fit the bioptic. Depending on the patient's visual acuity, visual field, central scotomas, ocular dominance, pupillary distance, and other physical factors, the bioptic is carefully designed to optimally fit the patient's face and provide an appropriate level of magnification. Because many factors (visual, cognitive, motor) contribute to safe driving with a bioptic, patients should be screened and evaluated to determine their overall eligibility for using the device. It is possible for patients to

meet the vision requirements for bioptic driving, but lack the cognitive, motor, or visual processing ability to use the device effectively. Patients with non-progressive, stable ocular conditions are in a favourable position but will need to demonstrate safe driving performance in terms of visual attention. Thus, cognition, motor function, and visual processing all play an integral role in the assessment of bioptic driving eligibility especially for elderly drivers.

The bioptic controversy

In the past, the use of bioptics had been somewhat controversial, beginning with Fonda's article that described bioptic use while driving as hazardous.¹³

Some have noted that bioptics cause a ring scotoma, as the patient views the magnified image projected over their normal central view.^{12–14} Other barriers that have been mentioned include induced parallax, reduced reaction time, restricted visual field with magnification, and difficult use with mirrors.¹⁴

The evidence regarding the safety and efficacy of bioptic use is still unclear, as some controlled studies show its advantages whereas others elucidate its challenges.^{2,12,15,16} Specifically, one study involving bioptic drivers in Massachusetts¹⁷ suggested that they were safe drivers when compared with the general population, whereas another study presented some concerns in Texas.¹⁸ Owsley points out that some of these studies are dated, have limitations in research design, and did not involve training programs with updated technological advances.¹⁶ Thus, it is difficult to draw meaningful conclusions with such conflicting evidence and dated models.

Some critics also believe that patients may be using the bioptics to only pass the driving test and not fully adopting the device while driving.^{13,19} In Owsley's recent investigation, the majority of a sample reported using their device to improve driving performance, contrary to this proposed belief.² Likewise, in a previous study, it was noted that more than half of the bioptic drivers observed were frequently utilising the telescope for spotting while driving.¹⁹

Recent investigations seem to emphasise the importance of assessing the comprehensive individual in regards to not only their visual function but also their visual processing, cognitive, and motor functions. These factors in addition to other contextual factors such as the patient's age and medical history provide a more complete picture in determining the risk level for driving. Ultimately, it is more useful to determine if they are a visually fit driver when taking these other factors into consideration in the context of their vision impairments. In addition to eye care providers, physiatrists, physical/occupational therapists, and/or certified driving rehabilitation specialists are other professionals who can assist in the assessment when investigating these other factors.

Challenges

Historically, visual acuity and visual field measurements have been viewed as the main objective factors in determining a patient's eligibility for driving. Ironically, there exists a research paradox, as some investigations have shown that these measures have little value in predicting vehicle collisions.^{2,16,20} Several studies have demonstrated that other quantitative measures such as contrast sensitivity and useful field of view (UFOV) are more accurate for determining a patient's level of risk for driving with a vision impairment.^{15,21} In addition to visual acuity and visual field measurements, visual processing tasks for determining driving risk may be under-utilised in determining a patient's eligibility, as the state licensing offices may rely on the seemingly obvious measures.

It has been noted that visual fields impact the risk level for driving, but the difficulty lies in elucidating to what extent.²⁰ Additionally, the exact impact that each of these factors (visual acuity, visual field, contrast sensitivity, colour vision) combined may have on the level of risk is unclear. For example, is it riskier for a patient with moderate visual acuity and visual field loss or for a patient with moderate visual acuity, marked colour vision, and mild contrast sensitivity loss to be on the road? Studies have investigated the impact of some of these objective measures and mostly demonstrated that all of these factors noted are somewhat relevant.²⁰ Prioritising which (combination of) factors have the most impact and quantifying the limits that hold significance in predicting vehicle collisions have posed a large challenge for researchers.¹⁶

Developing cost-effective bioptic training strategies and programs has also posed a challenge for investigators and clinicians. The task of evaluating driving performance is complex and multi-faceted.¹⁶ The numerous factors that impact driving performance complicate the method of analysing the outcome and efficacy of these bioptic training programs. Some investigators have utilised video surveillance to analyse bioptic driving performance, including head and eye movements.²³ Also, surveys involving how low-vision patients are using audio cues from Global Positioning Systems (GPS) to improve driving performance provide valuable insight about how technology is helping bioptic

drivers.²⁴ These surveys have shown that many patients benefit from the audio cues to prepare for lane changes and turns while bioptic driving. These audio cues minimise the visual demand required to use the bioptic to spot distant street signs.

Countries where bioptic driving is legal

Bioptic driving originated in the United States but has since been adopted in The Netherlands and in Canada.² In 2006, a demonstration project was completed in The Netherlands to investigate patient outcomes of a bioptic driving training program.²² The outcomes were found to be favourable. Based on the results, bioptic use was legalised in the country for patients with visual acuity between 20/40 and 20/160. Specific requirements were set for night-time driving privileges as determined by an adaptometre and/or C-Quant stray light metre.²²

The laws surrounding bioptic driving vary within countries. Some states/provinces allow bioptics to be used to pass the driving test. Others have more stringent guidelines that allow bioptic driving in their state/province but do not allow them to be used to meet the vision cut-offs. For example, in Canada, bioptic driving is allowed to pass the vision test in Manitoba, Northwest Territories, and Nunavut. However, they are only allowed for driving and not issued to those that live in Quebec. Thus, if patients do not meet the minimum vision requirements, they are not allowed to use a bioptic to improve their visual acuity to qualify for driving. They may use a bioptic if they have a mild vision impairment, but they must still meet all vision standards without the use of a telescopic aid. The same scenario is true for Florida, Pennsylvania, Wisconsin, New Mexico, Hawaii, and Missouri; patients who claim residency in these US states are not able to meet the vision requirements with a bioptic but may use

them for driving if they meet vision standards without the use of the aid.

Some countries do not clearly comment on bioptic use and may permit the use of “optical corrections” to meet vision standards. This ambiguity in wording causes uncertainty for some low-vision patients.

Common types of bioptics used for driving

There are numerous types of bioptic telescopes and several manufacturers. Some examples of commonly used telescopes in the United States (that are mounted in spectacles to create a bioptic) are the 3 × wide angle telescope, 2.2 × standard telescope, 3 × vision enhancing system (VES) mini, 4 × VES sport, and 2.2 × sightscope (Table 1).

Depending on the bioptic design, the two types of telescopes that are mounted on spectacles are Galilean and Keplerian. Galilean telescopes come in lower magnification powers with smaller fields of view but are shorter and lighter than Keplerian designs. Keplerian designs tend to be longer and heavier but allow for higher magnification, larger fields of view, and better image quality. Each presents its own advantages for patients; low vision specialists will consider the overall visual function of patients to choose the appropriate magnification level and type of bioptic design best suited for patients.

Current technology trends and implications

Technology is constantly advancing, and visually impaired patients are already incorporating these advances to improve their efficiency.^{24–26} Cars have monitors with audio cues to assist drivers when parallel parking. GPS systems are more readily integrated into vehicles. The process of driving a vehicle continues to become more automated. Google and other automotive companies will release new prototypes for self-driving vehicles in

Table 2. Common types of bioptic telescopes used for driving.

Name	Manufacturer	Type	Visual field*
3 × wide angle telescope	Designs for Vision	Galilean, fixed-focus	11°
2.2 × standard telescope	Designs for Vision	Galilean, fixed-focus	12°
3 × VES-mini telescope	Ocutech	Keplerian, focusable	15°
4 × VES-sport telescope	Ocutech	Keplerian, focusable	12.5°
2.2 × sightscope	Ocutech	Galilean, fixed-focus	18°

*Degrees for monocular field of view.

the near future.²⁷ As these technological advances become a reality, bioptic drivers will still need to use their device. Although the visual demand required to drive one of these vehicles will be less, visually impaired drivers can still benefit from improved distance acuity via periodic spotting through their mounted telescope.

Until self-driving cars become mainstream, more investigations defining effective bioptic driving training methods would help low vision specialists. There will continue to be a market for improved bioptic devices that maximise field of view, minimise weight and size of device, and optimise clarity of the magnified image. Lastly, more controlled studies confirming which visual factors and to what extent are the most useful in accurately determining a patient's risk level for motor vehicle accidents are critical to protect patients participating in bioptic driving.

Conclusion

Although some critics may consider bioptic driving hazardous, many have seen the clinical benefit the device provides for required visual tasks while driving. The authors believe it is critical to thoroughly evaluate each patient to determine whether they are a suitable or poor candidate for bioptic driving. Cognitive factors are always important to consider in assessing a patient's suitability as visual processing ability is vital in order to react appropriately during unexpected events while driving. This is especially important when dealing with elderly patients. Bioptic driving has the potential to become hazardous when patients are poor candidates to adopt its practice or when proper rehabilitation and training with the device has not been completed.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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