

**Bilateral cataract, crash risk, driving performance and self-regulation practices among  
older drivers: a review of the literature**

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## **Abstract**

This comprehensive literature review aims to summarise published studies examining cataract/ cataract surgery and driving outcomes, in order to identify gaps in the literature that necessitate further research.

Six electronic databases were searched for articles published up to and including March 2015. Articles were reviewed if they included older drivers with cataract or drivers who had undergone cataract surgery and at least one of the following driving outcomes: a) crash risk; b) driving self-regulation practices; c) driving performance.

There was consistent evidence that cataract negatively impacts on driving and that cataract surgery is beneficial for driving outcomes.

Future research should examine the separate effects of first and second eye cataract surgery on crash risk, driving self-regulation and driving performance. It should also aim to determine how visual measures relate to driving performance among cataract patients so that those most at risk of driving difficulties can be identified, advised and possibly prioritised for surgery.

## **Introduction**

Cataract is one of the leading causes of visual impairment globally, accounting for 33% of impairment.<sup>1</sup> It is also one of the leading causes of blindness with approximately 20 million people blind due to cataract.<sup>2</sup> Cataract surgery is one of the most common eye surgeries<sup>3</sup> and it is widely accepted that it brings about significant improvements in vision.<sup>4</sup>

It is predicted that by 2030, one quarter of individuals driving will be aged 65 years or older due to the ageing population.<sup>5</sup> Older drivers are more likely to drive a vehicle and less inclined to use public transport than they were a decade ago.<sup>6</sup> Driving often represents an important social role for older adults and previous research has linked driving with independence, self-worth and the ability to stay engaged with society and life.<sup>7</sup> Indeed, it has been found that older drivers more than younger drivers, feel that driving is important for maintaining their independence, mobility and flexibility.<sup>8</sup> In addition, driving cessation has been linked to depression in this age group.<sup>9</sup>

Driving is a complex task, requiring many different aspects of visual functioning.<sup>10</sup> It has been suggested that vision is responsible for 90 to 95% of the sensory input required for driving<sup>11</sup> and cataract can negatively affect different aspects of vision such as contrast sensitivity and visual acuity, potentially having serious consequences for driving ability.<sup>12</sup> Despite the increasing number of studies reporting on the impact of cataract on different driving outcomes, significant gaps in the evidence still exist. Due to the ageing population, the effect of cataract surgery on driving outcomes is of particular relevance and concern. This comprehensive literature review aims to summarise previously published literature examining cataract/ cataract surgery and driving outcomes including crash risk, driving self-regulation and driving performance. Studies examining visual measures associated with these outcomes will also be

reviewed. This will enable researchers to identify gaps in the literature that necessitate future research.

## **Methods**

A review of databases such as MEDLINE, Ovid, CINAHL, ScienceDirect, Taylor & Francis, and SpringerLink, was undertaken between February and March 2015. The following keywords were used individually and in all possible various combinations: “*cataract*”, “*bilateral cataract*”, “*visual impairment*”, “*vision*”, “*driving performance*”, “*driver self-regulation*”, “*crash risk*”, “*motor vehicle crash*”, “*road crashes*”, “*accident*”, “*driver safety*”, “*fitness to drive*”, “*older drivers*”, “*ageing population*”, “*aged drivers*”, “*senior drivers*”, and “*cataract surgery*.” Additional articles were also selected from cited references included within these articles. All articles in this review originally appeared in scientific English language journals, books or reports published between 1997 and 2015 and were available online. Articles were reviewed if they included older drivers with cataract or drivers who had undergone cataract surgery and at least one of the following driving outcomes: a) crash risk; b) driving self-regulation practices; c) driving performance. All study designs were included. The researchers excluded articles from this literature review if they were not in English, were unpublished or were theses.

## **Results**

Three studies were reviewed examining cataract/ cataract surgery and crash risk, two examining driving self-regulation and 15 studies and one meta-analysis examining driving performance outcomes.

### Cataract and Crash Risk

Three studies were located examining cataract/ cataract surgery and crash risk or visual measures associated with crash risk. Results were published in seven articles.

A recent population-based linked database study analysed the impact of first-eye cataract surgery on motor vehicle crash risk in Western Australia and found a 12.7% reduction in crash risk in the year following first-eye cataract surgery, which accounted for community cost savings of A\$4.3 million.<sup>13</sup> However, when examined by gender, the researchers found no significant reduction in crash risk after first-eye cataract surgery for females.<sup>14</sup>

The prospective Impact of Cataract on Mobility (ICOM) Project conducted in the United States of America (USA), found that older drivers with cataract were almost 2.5 times as likely to have had an at-fault crash in the previous five years than those without cataract (relative risk (RR)=2.46, 95% confidence interval (CI)= 1.00-6.16).<sup>15</sup> A subsequent follow-up study over a four to six year period reported that cataract patients who underwent surgery experienced only half the crash risk of cataract patients who did not have surgery (RR=0.47, 95% CI= 0.23-0.94).<sup>16</sup> It should be noted that this study is limited by the small sample size of 174 drivers who had surgery and 103 controls, and the subsequent low number of at-fault crashes recorded. This study also combined those who had first eye cataract surgery (44%) and those who had both eye surgeries (56%) during the study period in the analysis.<sup>16</sup> Since the majority of cataract cases are bilateral, it still remains unclear whether first eye surgery alone reduces crash risk and whether second eye surgery provides additional benefits for crash risk reduction.

Recently, a model was developed based on data from the ICOM Project to simulate the motor vehicle crash experience of the older US population.<sup>17</sup> This study reported that performing

cataract surgery at an earlier stage than the current practice, would decrease the average number of motor vehicle crashes, deaths and costs associated with crashes by approximately 21%.<sup>17</sup>

To date, the ICOM project is the only study to examine the association between visual measures and crash risk for cataract patients. Owsley et al.<sup>12</sup> reported that reduced contrast sensitivity was the only independent predictor of crash involvement in the previous five years and the relationship was stronger for worse eye contrast sensitivity than better eye Visual acuity and disability glare measures were not associated with crash risk.<sup>12</sup>

#### *Cataract and driving self-regulation practices*

Self-regulation is a complex<sup>18</sup> and multi-dimensional process<sup>19</sup> that experts consider a positive coping strategy that enables individuals to reduce driving risk.<sup>8</sup> The concept of driving self-regulation assumes that as certain driving situations become more difficult for an older person due to functional decline, they will restrict their driving practices to situations in which they feel safe.<sup>20</sup> Previous studies found that visual impairment, including impairment in visual acuity, contrast sensitivity, stereopsis and visual field, were associated with driver self-regulation.<sup>21, 22</sup> However, other studies reported that a significant proportion of high risk drivers, including those with visual impairments, did not practice driving self-regulation.<sup>23</sup> While it is probable that drivers with cataract may adjust or self-regulate their driving practices as a result of their impairment, there has been minimal research in this area.

Only two studies, with results published in three articles were located that specifically examined cataract/ cataract surgery and driver self-regulation. Owsley et al.<sup>15</sup> used the Driving Habits Questionnaire to examine the driving habits of 279 older drivers with cataract, and 105 with no cataract. They reported that those with cataract had significantly

reduced days of driving and destinations compared to those without cataract, but cataract was not related to driving less kilometres per week.<sup>15</sup> The authors concluded that older adults with cataract were significantly more likely to restrict their driving habits than those without cataract.<sup>15</sup>

An Australian study<sup>24</sup> examined the driving self-regulation practices of 99 drivers aged 55 years and older with bilateral cataract also using the Driving Habits Questionnaire.<sup>15</sup> It was found that 48% reported self-regulating their driving to avoid at least one challenging situation and the situations most commonly avoided were driving at night (40%), on the freeway (12%), in the rain (9%) and parallel parking (8%).<sup>24</sup> The same study reported that after first eye cataract surgery, the average driving exposure for participants increased by 22 km per week.<sup>25</sup> It was also found that contrast sensitivity in the worse eye was significantly associated with driver self-regulation before cataract surgery.<sup>24</sup>

### *Cataract and driving performance outcomes*

Despite evidence for decreased crash risk with cataract surgery, there is less understanding of the impact of cataract/ cataract surgery on driving performance. To date, studies have examined the impact of cataract/ cataract surgery on self-reported driving difficulty or closed-road driving performance.

### *Self-reported driving difficulty*

A total of 11 studies and one meta-analysis were identified examining cataract/ cataract surgery and self-reported driving difficulty or visual measures associated with driving difficulty, with results published in a total of 15 articles.

The majority of studies evaluating the impact of cataract and cataract surgery on driving performance outcomes have examined self-reported driving difficulty using instruments such as the Activities of Daily Vision Scale (ADVS),<sup>26</sup> Visual Function Index (VF-14),<sup>27</sup> National Eye Institute Visual Function Questionnaire (NEI VFQ-25)<sup>28</sup> or the Driving Habits Questionnaire.<sup>15</sup> Many studies have reported increased self-reported driving difficulty with cataract. Specifically, a recent study reported that drivers with cataract had more difficulties with parallel parking, driving in heavy traffic, driving at night and driving in rush hour than did drivers without cataract.<sup>29</sup> Owsley et al. reported earlier that drivers with cataract also had difficulty driving in the rain, alone and on interstates.<sup>15</sup>

One meta-analysis (including data from five studies) and 6 additional studies were located that examined the impact of cataract surgery on self-reported driving difficulty. These studies are detailed in table 1. The meta-analysis reported a 88% decrease in self-reported driving difficulties after cataract surgery.<sup>30</sup> This meta-analysis included data from five studies conducted in the United States, India and Sweden. One of these was retrospective<sup>31</sup> and four were prospective.<sup>32-35</sup> Six additional studies examining the impact of cataract surgery on self-reported driving difficulty also all reported overall improvements following surgery.<sup>16, 25,36-39</sup>

It should be noted however, that several of these studies measured driving difficulty with general questionnaires that contained only two driving-related items addressing day and night driving. In addition, most of the studies did not define whether participants had undergone surgery on the first, second or both eyes, or analysed all participants together. Therefore, the separate effects of first and second eye cataract surgery on driving difficulty remain inconclusive.



Two of the above studies analysed driving difficulty following first eye surgery specifically and found that driving difficulty worsened for a significant proportion of bilateral cataract patients.<sup>25,37</sup> A recent Australian study found that while self-reported driving difficulty improved overall among bilateral cataract patients after first-eye cataract surgery, 16% did not improve and driving difficulty worsened in 11%.<sup>25</sup> Similarly a prospective study reported that 11% and 7% of cataract patients respectively reported more difficulty with day and night driving after first eye surgery and 14% reported no improvement with night driving.<sup>37</sup>

Four studies have examined visual measures associated with self-reported driving difficulty among cataract patients, with conflicting results. Two reported that contrast sensitivity was the measure most strongly associated with driving difficulty,<sup>25,40</sup> one reported visual acuity was the only measure associated<sup>41</sup> and another reported that contrast sensitivity and visual acuity both predicted change in driving difficulty after surgery.<sup>39</sup> Stereopsis and disability glare were not found to be associated with self-reported driving difficulty<sup>25,39,41</sup>.

#### *Closed-road driving performance*

Four studies were identified that examined that impact of cataract on closed-road driving performance. One of these also examined the impact of cataract surgery and visual measures on driving performance.

Three studies have used goggles to simulate the effects of cataract and examined driving performance on a closed-road circuit. A study of 20 younger and 20 older drivers free of ocular pathology reported poorer overall driving scores and difficulties recognising traffic hazards on a closed road circuit during the day when wearing the cataract simulating goggles.<sup>42</sup> Another study of 20 younger drivers on a closed road circuit at night time reported that the cataract

goggles significantly increased the time taken to complete the circuit and reduced recognition of road signs and avoidance of road hazards.<sup>43</sup> The most recent study of 28 younger drivers found that simulated cataract impairment significantly reduced the frequency of recognition of pedestrians and the distance they were recognised at, under night conditions.<sup>44</sup>

An earlier study compared the closed-road driving performance of 29 older drivers with bilateral cataract to 18 controls with normal vision.<sup>45</sup> Those with cataract had significantly poorer overall driving performance, road sign recognition, hazard recognition and hazard avoidance.<sup>45</sup> This was also the only study identified which examined the impact of cataract surgery on closed-road driving performance. Wood and Carberry<sup>45</sup> found that overall driving performance improved after bilateral cataract surgery and that participants were better at avoiding and recognising hazards as well as recognising road signs. The study found that the improvement in contrast sensitivity in the second operated eye predicted the positive changes in driving performance.<sup>45</sup>

## **Discussion**

This review of the impact of cataract and cataract surgery on driving outcomes including crashes, driving self-regulation and driving performance provides consistent evidence that cataract negatively impacts on driving and that cataract surgery is beneficial for driving outcomes.

In terms of quality of the studies reviewed, all were observational study designs which exposes them to bias, including selection bias. However, since it is difficult and may be unethical to randomise cataract patients to surgery/ no surgery groups, observational study designs represent the best method for studying the impact of cataract and cataract surgery on driving

outcomes. The majority of studies examining the impact of cataract surgery used prospective designs, reducing the risk of bias and confounding. However, several of the prospective studies reviewed had small sample sizes of less than 100.<sup>25,35,36,38</sup> One of the studies examining cataract surgery and crash risk used a retrospective population-based design.<sup>13</sup> While this study was unable to capture detail such as visual measures, it had the advantage of a large sample size.<sup>13</sup> Several studies reviewed also did not have comparison groups, exposing them to confounding.<sup>13,25,31-36</sup> Overall, the studies reviewed examining the impact of cataract surgery on crash risk, driving self-restriction and closed-road driving performance used appropriate or validated measures of these outcomes. However, the 11 studies examining self-reported driving difficulty used five different questionnaires to assess this outcome (see table 1), some of which only used two driving questions addressing day and night driving and had not been validated as measures of driving difficulty.

Despite positive findings overall, significant gaps in the evidence still exist. Many of the observational studies reviewed did not define whether participants had undergone surgery on the first or second eye or analysed both eyes together. Therefore, the separate effects of first and second eye surgery on crash risk, self-regulation and driving performance remains inconclusive. While first eye surgery has shown to bring about significant improvements in vision, patients frequently report problems while waiting for second eye surgery, most likely due to differences in vision between the operated and un-operated eyes. Since bilateral cataract patients in some public health systems who opt to have both eyes operated on may wait six months to a year or more between surgeries, this implies that they drive for substantial periods of time while waiting for second eye surgery.<sup>46</sup> This highlights the importance of fully understanding the specific aspects of driving performance affected by cataract and by first and second eye cataract surgery. Information on the impact of second eye cataract surgery on

driving outcomes and self-regulation practices is particularly lacking. It is also important to determine whether second eye surgery provides any specific additional benefits for driving performance or crash risk and for which groups of patients it is effective.

Further research using a detailed and validated driving difficulty questionnaire would provide valuable information on the specific driving difficulties bilateral cataract patients experience before and after first and eye surgery and how surgery influences these. The closed-road studies reviewed provide useful preliminary information on the impact of cataract and cataract surgery on specific aspects of driving performance.<sup>42-45</sup> However, these studies are limited by small sample sizes. Driving simulators also offer a safe and effective method for examining the impact of eye disorders on driving performance and to date, have not been used specifically for older people with cataract. Driving simulation represents an approach that is repeatable and easily adaptable - including the ability to quickly alter driving scenarios and expose drivers to hazardous situations in a systematic way.<sup>47,48</sup> They can also be configured specifically to test particular components of the driving task thought to be problematic for people with cataract.<sup>49,50</sup> A large simulator study would provide useful information on changes in driving performance throughout the cataract surgery process.

Evidence from two studies suggests that older drivers with cataract may self-regulate their driving before surgery,<sup>15, 24</sup> possibly reducing their risk of a crash. However, there is currently no information on how older drivers with cataract self-regulate their driving throughout the cataract surgery process and whether their self-regulation practices are actually associated with actual driving performance. In recent years, a growing number of studies have started to use in-vehicle monitoring devices to assess naturalistic driving patterns and self-regulation practices, as opposed to using self-reported information which may be subject to bias.<sup>19, 51-53</sup>

To date, there is no research that has used in-vehicle driver monitoring devices to measure self-regulation practices among cataract patients.

A small number of studies examined visual measures associated with crashes, self-regulation and driving performance<sup>12, 24,25,39-41,45</sup>. Results were somewhat inconsistent and this may be due to small sample sizes and varying use of better eye and worse eye values for visual measures. Despite this, contrast sensitivity is emerging as potentially important measure that may be predictive of crash risk, driver self-regulation and driving performance. Contrast sensitivity however, is not currently used in visual testing for licensing, for prioritisation of patients for cataract surgery or assessing the success of surgery. Therefore, it is essential that future research investigate in-depth how visual measures (including contrast sensitivity) relate to driving outcomes before between and after cataract surgeries.

Finally cataract surgery often necessitates a change in spectacle prescription, which may impact driving performance. Recent research by Fraser et al.<sup>54</sup> found that only 22% of 99 bilateral cataract patients had purchased new glasses after their first eye surgery. Most bilateral patients requiring new glasses held off purchasing new glasses until after their second eye surgery due to the expense, resulting in the group driving with less than optimal vision. There is minimal research examining the impact of refractive management on driving performance before, between and after cataract surgery.

In conclusion, while research to date agrees that cataract surgery provides benefits for driving outcomes, important gaps in the evidence remain. Future research should examine the separate effects of first and second eye cataract surgery on crash risk, driving self-regulation and driving performance. It should also aim to determine how visual measures relate to driving

performance among cataract patients so that those most at risk of driving difficulties can be identified, advised and possibly prioritised for surgery.

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**Table 1: Studies examining the impact of cataract surgery on self-reported driving difficulty**

<b>Study</b>	<b>Country</b>	<b>Study Design</b>	<b>Participants (drivers)</b>	<b>Instrument</b>	<b>First or Second Eye Surgery</b>	<b>Findings</b>
Bevin et al. 2004 <sup>36</sup>	New Zealand	Prospective cohort	- 29 surgery - No controls	- VF-14	Not specified	- Significant decrease in proportion experiencing difficulty with day and night driving after surgery
Castells et al. 1999 <sup>37</sup>	Spain	Cohort analysis of RCT	- 249 first eye surgery - 66 second eye surgery	- VF-14	First and second eye analysed separately	- Majority of first eye and all of second eye group improved in day and night driving score after surgery
Chang-Godinich et al. 1999 <sup>31</sup>	USA	Retrospective	- 101 surgery - No controls	- ACDCF	First and second eyes combined	- Significant improvement in driving problems after surgery
Elliot et al. 2000 <sup>38</sup>	Canada	Prospective cohort	- 17 first eye surgery - 25 second eye surgery - 25 no cataract	- ADVS	First and second eye analysed separately	- Significant improvement in day and night driving scores after first eye surgery - Significant improvement in night driving score only after second eye surgery
Fraser et al. 2013 <sup>25</sup>	Australia	Prospective cohort	- 99 first eye surgery - No controls	- DHQ	First eye surgery	- Significant improvement in driving difficulty score after first eye surgery
Mamidipudi et al. 2003 <sup>32</sup>	India	Prospective cohort	- 116 surgery - No controls	- NEI VFQ-25 (modified)	Not specified	- Significant improvement in day and night driving after surgery

McGwin et al. 2003 <sup>*39</sup>	USA	Prospective cohort	- 156 surgery - 89 no surgery	- ADVS	First or both eyes combined	- Significant improvement in day and night driving scores for surgery group after surgery - No significant change in scores for non-surgery group
Mönestam & Wachtmeister 1997 <sup>35</sup>	Sweden	Prospective cohort	- 19 surgery - No controls	- Not specified	First, second or both eyes combined	- Significant decrease in proportion experiencing visual problems while driving after surgery
Mönestam et al. 2005; <sup>34</sup> Mönestam & Lundqvist 2006 <sup>33</sup>	Sweden	Prospective cohort	- 189 surgery - No controls	- VF-14 - Additional items	First, second or both eyes combined	- Significant decrease in proportion experiencing any difficulty with day and night driving five years after surgery - No significant difference in driving difficulty between those who had first or both eye surgeries
Owsley et al. 2002 <sup>*16</sup>	USA	Prospective cohort	- 174 surgery - 103 no surgery	- DHQ	First or both eyes combined	- No significant difference between groups in driving difficulty at first annual follow up after surgery - Significantly less driving difficulty for surgery group at second annual follow up

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Instrument abbreviations: ACDCF, Cataract Data Collection Form; ADVS, Activities of Daily Vision Scale; NEI VFQ-25, 25 Item National Eye Institute Visual Function Questionnaire; VF-14, Visual Function Index

\* Results from same study using different measurement instruments