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The consequences of strabismus and the benefits of adult strabismus surgery

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Abstract

Strabismus has a negative impact on patients' lives regardless of their age. Factors such as self-esteem, relationships with others, education and the ability to find employment may all be negatively affected by strabismus. It is possible to correct strabismus in adulthood successfully; the chances of achieving good ocular alignment are high and the risks of intractable diplopia low. Successful surgery to realign the visual axes can improve visual function, and offer psychosocial benefits that ultimately improve quality of life. The potential benefits of strabismus surgery should be discussed with patients, regardless of their age or the age of onset of strabismus. This article reviews the impact of strabismus, focusing on the psychosocial consequences of the condition, of which many optometrists may be less aware.

Introduction

Strabismus, an abnormal alignment of the eyes, affects approximately one in 20 people (Stidwill 1997). Adult-onset strabismus may be caused by cranial nerve palsies or mechanical restriction of the extraocular muscles. It can be associated with trauma or systemic diseases, such as stroke or thyroid disease. Strabismus in adulthood can also simply be the result of a congenital strabismus or a deviation that developed during the first few years of life, which was either missed or has increased in size since treatment. Strabismus leads to many negative functional and psychosocial consequences, which can be obviated by surgery (Durnian et al. 2011). Despite this, adults with strabismus often delay treatment. Coats et al. (2005) found that, for patients in whom strabismus develops before 9 years of age, the average delay in seeking treatment is 29 years. For patients with later-onset strabismus, the average delay is 10 years. In both groups, the delay is substantial. A key reason for delaying treatment included surgery not being offered by eye care practitioners (Coats et al. 2005).

Optometrists may be reluctant to refer adults for strabismus surgery for a number of reasons, including a misconception that treatment is unavailable to adults, that there is a high risk of intractable diplopia associated with correction of adult strabismus, or that adult strabismus surgery is purely cosmetic. This article primarily reviews the psychosocial impact of strabismus, which optometrists may be less familiar with. It also provides information on the potential risk of diplopia and benefits associated with adult strabismus surgery.

Consequences of strabismus

In the following sections we outline the major impacts of strabismus on a range of functional and social activities that many of us take for granted.

Visual consequences

Patients with strabismus may experience diplopia, impaired depth perception, asthenopia and difficulty driving (Beauchamp et al. 2003). Patients with esotropia may suffer from a reduced binocular field of view, while those with exotropia may experience a panoramic field of view (Wortham and Greenwald 1989). Strabismus commonly results in amblyopia, which itself presents a range of deficits in spatial vision (McKee et al. 2003) and impairments in motor control that can limit performance on real-world visuomotor tasks (Grant and Moseley 2011). Reduced binocularity due to strabismus can lead to greater risks of falls and injuries in the elderly (Pineles et al. 2015b).

Diplopia is a particularly problematic issue that interferes with everyday tasks and can prevent patients from driving (Righi et al. 2014). Strabismus that occurs early in life may give rise to amblyopia, but is less likely to result in diplopia due to mechanisms of interocular suppression. This, however, does not mean that patients with early-onset strabismus will not develop diplopia. In a multicentre retrospective study involving 299 patients who underwent strabismus surgery, nearly a third of patients with strabismus that developed before 9 years of age complained of diplopia (Beauchamp et al. 2003). The most common reason for diplopia

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developing in patients with childhood-onset strabismus is a change in the angle of deviation (Kushner 2001).

Patients with strabismus may therefore suffer from a range of visual problems and the specific symptoms experienced by individuals will depend on patient-specific factors such as the age of onset of strabismus, the type of deviation and its magnitude.

Communication

Eye position and eye movements indicate where someone is directing attention and play an important role in communicating with others. Humans are unique in having a large region of exposed non-pigmented sclera, which is paler than both the iris and the surrounding skin (Kobayashi and Kohshima 1997). This evolutionary specialisation enhances the ability to determine where others direct their gaze and highlights the importance of gaze signalling in human communication (Kobayashi and Kohshima 2001). Figure 1 shows the area of exposed sclera and scleral colour in humans and two other primates. Eye movements allow individuals to pick up on social cues, but also broadcast social signals. For example, gaze cues play an important role in the complex sequence of speaking and listening that occurs during conversations (Kleinke 1986). Speakers make regular fixations to listeners to ensure that they are paying attention, but fixations also serve as signals to both parties in a conversation (Foulsham 2015; Ho et al. 2015).

People with strabismus often report problems making eye contact when speaking with others (Nelson et al. 2008; Satterfield et al. 1993). Abnormal gaze cues associated with strabismus may explain why they have more difficulty in social situations and why others develop negative impressions of them. Olitsky et al. (1999) asked people to evaluate photos of a person with large-angle (50ΔD) esotropia or exotropia with regard to characteristics important in personal relationships and employment opportunities, including communication skills. Their findings indicate that people with strabismus are judged as having significantly poorer communication skills compared to those without strabismus.

It is also possible that people with strabismus receive abnormal gaze cues from individuals they are speaking to, because the other party is not sure which eye to focus on, or where the person is fixating. Indeed, it has been shown that people with strabismus perceive eye contact differently than orthotropic individuals and this effect persists even after strabismus surgery (Babar et al. 2010). Thus, communication in individuals with strabismus may suffer because they are both sending and receiving atypical gaze cues.

Patients with strabismus report consciously employing methods to conceal their strabismus from other people, for example by wearing sunglasses, rubbing their eyes or adopting an abnormal head posture (Menon et al. 2002). These behaviours may further hinder eye contact and compound communication problems.

Education

There is evidence that a strabismic appearance may have a detrimental impact on an individual's experience in education. When teachers were asked to rate personal characteristics of students depicted in photos, the presence of strabismus played an important role (Uretmen et al. 2003). In some sessions, teachers were shown photos in which a given student appeared orthotropic. In other sessions, teachers were shown photos that were altered so that the student appeared to have strabismus. The result of this manipulation was that teachers rated the personal characteristics of children with strabismus – including their intelligence, capacity for hard work and happiness – more negatively than photos of the same children when they appeared orthotropic.

The results from Uretmen et al. (2003) were based on a simulated deviation of 45ΔD and are therefore more relevant to large-angle deviations. Further, the evidence for educational impact is indirect. Although the attitudes of teachers towards students were clearly modified by the presence of strabismus, there is no evidence that they would treat these students any differently or in a way that would subsequently affect their educational achievements.

A study investigating the effects of amblyopia on education

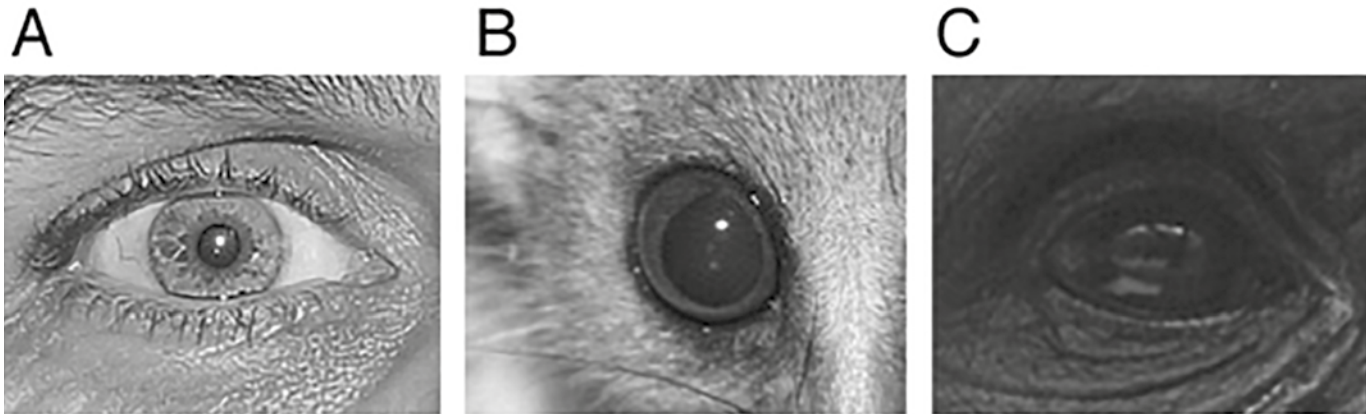

Figure 1. Humans have the largest region of exposed sclera and the sclera is paler than the iris and surrounding skin. Comparison of scleral coloration and exposed scleral region in (A) humans; (B) mouse lemurs, the smallest primates; and (C) gorillas, the largest primates. (Adapted from Haverkamp (2007) and Kobayashi and Kohshima (2001).)

in people from the 1958 British birth cohort showed that strabismus in the absence of amblyopia did not affect educational outcomes (Rahi et al. 2006). The effect of amblyopia, which often occurs with strabismus, on education is less clear. Rahi et al. (2006) found that amblyopia did not affect educational outcomes. In contrast, an analysis of the consequences of amblyopia on participants in the Blue Mountains Eye Study showed that fewer people with amblyopia attained higher university degrees compared to people with normal vision (Chua and Mitchell 2004).

Employment

Since strabismus alters gaze-holding patterns and communication, it may put people at a disadvantage in public-facing careers and during job interviews (Hunter 1995). In support, there is indirect evidence from recruitment consultants suggesting that strabismus makes it more difficult for an individual to gain employment, regardless of the visual requirements of a given job (Coats et al. 2000; Mojon-Azzi and Mojon 2009).

When interviewed, employment 'headhunters' indicated a role for strabismus when it comes to hiring preferences (Mojon-Azzi and Mojon 2009). Photos of individuals with large-angle (50ΔD) strabismus and other facial abnormalities were available to view by 40 recruitment consultants. They were asked their opinion on the effect of strabismus on 11 different personality traits. Nearly three-quarters of those interviewed expressed a view that people with strabismus have more difficulty finding employment. The detrimental effect of strabismus was greater for exotropia compared to esotropia and for women compared to men. The scores assigned to photos of people with strabismus suggest that they were perceived to be less attractive and less intelligent.

There is also evidence to suggest that strabismus not only reduces the ability to find a job, it also reduces the chances of promotion. Goff et al. (2006) investigated the effect of strabismus on the ratings given to individuals considered for promotion in the US Army. The promotion system in the US Army involves assessment of photos of individuals being considered for promotion to gauge military bearing and suitable wear of uniform. The researchers asked military officers to rate photos of individuals who appeared orthotropic or with 20ΔD of esotropia or exotropia. Esotropic individuals were rated less favourably than those who were orthotropic. Surprisingly, there was no difference in rating between orthotropic and exotropic individuals.

Diplopia resulting from strabismus will prevent individuals meeting vision standards for certain occupations, eg Royal Air Force or fork lift truck driver. Amblyopia associated with strabismus may also prevent individuals passing vision standards required for certain occupations, eg fire and rescue service or air traffic control officer (Adams and Karas 1999). Because the number of people in occupations with minimum visual acuity standards is small, fewer than four in 1000 people would be prevented from working in these occupations due to amblyopia – although this does not lessen the significance of failing an occupational vision standard to an individual with strabismus (Rahi et al. 2006).

Relationships

Strabismus can have a negative influence on personal relationships. This begins at an early age, when relationships between children and parents form, through to adulthood, when relationships with friends and partners can be affected. Mothers with children who have strabismus are less likely to develop a supporting relationship with their children and show a greater tendency for dissatisfaction and rejection of their maternal role compared to mothers with children who do not have strabismus (Akay et al. 2005; Lewis et al. in preparation). Note also that parents tend to underestimate the psychosocial effects of strabismus on their children (Sim et al. 2014).

Children and adults with strabismus experience derision from others as a result of their strabismus and feel that their strabismus affects friendships with others of the same and opposite sex (Satterfield et al. 1993). To investigate the influence of strabismus on finding a partner, one study interviewed 40 dating agents who were shown photos of people with simulated strabismus (50ΔD) or other facial abnormalities (Mojon-Azzi et al. 2008). More than 90% of the agents believed that people with strabismus would have more problems finding a partner. They also predicted that personality traits of people with strabismus would be perceived by potential partners as being less attractive, less likeable, less interesting, less successful and less intelligent.

Mental health problems

Individuals with strabismus are more likely to develop mental health problems (Jackson et al. 2006). In adults due to undergo strabismus surgery, the proportion of patients suffering from anxiety or clinical depression is 10 times higher than found in the general population, a rate similar to that for people with facial disfigurement and higher than patients with diabetes or rheumatoid arthritis (McBain et al. 2014b). It should be borne in mind that, since patients included in this study were listed to undergo surgery, these results are unlikely to be representative of people with strabismus in the general population. Indeed, quality of life has been shown to be higher in strabismic individuals not planning to undergo surgery compared to those who are (Beauchamp et al. 2005). Mohney et al. (2008) retrospectively reviewed the medical records of 407 patients who had strabismus in childhood and concluded that patients who have exotropia in childhood are more than three times more likely to develop a psychiatric disorder than control subjects by the age of 20 years. Those who had intermittent exotropia were more likely to have a history of mental health problems and 'suicidal or homicidal ideation'.

There is a strong association between strabismus and schizophrenia (Toyota et al. 2004). The latter is thought to be associated with neurodevelopmental abnormalities (Murray and Lewis 1987). This viewpoint is supported by the fact that there is a higher frequency of minor physical anomalies in schizophrenic patients compared to healthy individuals, including fused eyebrows, epicanthus, heterochromia irides (Ismail et al. 1998) and strabismus – more specifically, constant exotropia (Toyota et al. 2004). Here, strabismus is probably an effect of the general disorder, rather than a specific cause of the problems.

The communication difficulties experienced by people with strabismus and those with whom they interact, described earlier, may contribute to impairments in social functioning, social phobia and negative effects on mental health (Bez et al. 2009; McBain et al. 2014a). It is also possible that mental health problems themselves contribute to communication problems in these patients.

Quality of life

Many of the life domains mentioned above influence quality of life (Schalock 2004), so perhaps unsurprisingly, strabismus has been shown to have a negative impact on quality of life, via a combination of psychosocial and functional factors (Chang et al. 2015; Hatt et al. 2007). Different questionnaires have been used to assess quality of life in patients with strabismus. Results from questionnaires such as the Hospital Anxiety Depression Scale, the Derriford Appearance Score and the World Health Organization Quality of Life-BREF (WHOQoLBREF) questionnaire indicate that strabismus has significant negative effects on general anxiety, social anxiety and social avoidance (Jackson et al. 2006). Results from a questionnaire designed specifically for adults with strabismus, the AS20 (Hatt et al. 2009), correlate well with results from the more generic Derriford Appearance Score questionnaire and show that strabismus in adults negatively affects both functional and psychosocial factors that impact on quality of life (Durnian et al. 2009).

In a study investigating the impact of strabismus on quality of life, Beauchamp et al. (2005) found that the majority of people with the condition would be willing to trade part of their life expectancy in exchange for successful correction. The median proportion of remaining life expectancy willing to be traded was 7%. Poor quality of life is associated with an individual's perception that s/he has a larger visible angle of deviation, greater social anxiety and avoidance (McBain et al. 2014b), diplopia and asthenopia (Beauchamp et al. 2005). Strabismic individuals who are female or living in more deprived areas are also more likely to have lower quality-of-life scores (Durnian et al. 2010).

Esotropia vs. exotropia

The psychological impact (Ritchie et al. 2013) or quality-of-life effects (McBain et al. 2014b) do not appear to be dependent on whether deviations are convergent or divergent. However, some studies suggest that people with esotropia are perceived more negatively compared to those with exotropia (Goff et al. 2006; Olitsky et al. 1999; Uretmen et al. 2003) while others suggest the reverse (Mojon-Azzi et al. 2008). There is no clear pattern over the direction of the misalignment.

Females and males

Data from a number of studies show that the psychosocial effects of strabismus are greater for females than for males (Coats et al. 2000; Durnian et al. 2010; Goff et al. 2006). One study showed no difference in hiring preference between men with or without strabismus, yet othotropic females were ranked more highly than females with strabismus (Coats et al. 2000). In addition, females have greater expectations from strabismus surgery in terms of appearance-related issues (McBain et al. 2015) and as a result gain more from strabismus surgery than males (Burke et al. 1997; Glasman et al. 2013; Nelson et al. 2008). It has been suggested that this difference might reflect the negative influence of the idealised female image depicted by the general media (Durnian et al. 2011). In fact, placing a high value on appearance has previously been shown to be associated with poorer psychosocial quality of life in adults with strabismus (McBain et al. 2014b).

When do negative feelings towards people with strabismus develop?

Negative feelings towards people with strabismus develop early. To investigate this, children aged 3–7 years were given a toy doll that appeared to be orthotropic, esotropic or exotropic (Paysse et al. 2001). Children were observed for 10 minutes and then asked questions about their feelings towards the toy. Children aged 4½ years and younger did not notice a difference in appearance between the orthotropic and strabismic dolls. Those aged 4½–5½ years described the eyes of the strabismus and orthotropic dolls as different, but did not favour one over the other. In contrast, children aged 5¾ years and older provided negative descriptions of the dolls with strabismus. These older children were a staggering 73 times more likely to say they disliked the dolls with strabismus compared to younger children. Behaviour scores were calculated from the incidence of observed positive (eg kissing) and negative (eg throwing or hitting) behaviours towards the dolls. Children older than 5¾ years were over four times more likely to have an overall negative response towards the strabismic dolls when observed.

In a more recent study, investigators altered photographs of six children, creating six pairs of twins, with each twin either being orthotropic or having strabismus (Mojon-Azzi et al. 2011). Figure 2 shows photos of two children that have been altered using a similar method to create twins with strabismus. Over 100 children (aged 3–12) were asked which twins they would like to invite to their birthday party. Children younger than 6 years of age showed no bias towards inviting children with or without strabismus. However, older children were less likely to invite children with strabismus. These results support those from Paysse et al. (2001) and suggest that negative attitudes towards people with strabismus develop by around 6 years of age.

Figure 2. Example stimuli created using a similar method to that of Mojon-Azzi et al. (2011). Photos of orthotropic children (images on left) were digitally altered to create the appearance of a twin with strabismus (images on the right). Top right, exotropia; bottom right, esotropia.

What is the minimum angle of deviation that can be reliably detected?

The minimum angle of misalignment that can be detected by lay observers has implications in terms of defining a successful endpoint for corrective surgery. A number of studies have investigated the minimum detectable angle of deviation. Larson et al. (2003) digitally altered pictures to simulate different angles and found a similar detection threshold for esotropia and exotropia. In addition, they found that it was easier to detect strabismus in adults compared to children and that it was easier to detect horizontal deviations and hypertropia compared to hypotropia.

The ability to detect strabismus is likely to be influenced by specific facial characteristics and ethnicity. Chan et al. (2016) found that the ability to detect convergent or divergent deviations differed depending on the ethnicity of the model photographed. Exotropia was easier to detect in black and in white models; however, esotropia was easier to detect in East Asian models, perhaps due to larger epicanthal folds and wider nasal bridge. Note that exotropia is more common in East Asians, but esotropia is more common in white people (Chia et al. 2007). When information from all models was combined, it was easier to detect exotropia compared to esotropia. On average, 70% of people could detect exotropia of 16Δ D, whereas an esotropia had to be 19Δ D to enable detection by the same proportion of people (Chan et al. 2016).

Many of the studies described so far have simulated large deviations that are manifestly obvious. The angle of deviation (at least prior to surgery) has been found to be related to measures of anxiety and depression (Jackson et al. 2006) and other effects are likely to be influenced by the size of deviation. The mean (± SD) angle is 34 (±21) and 37 (±18) Δ D for esotropes and exotropes awaiting surgery respectively (Beauchamp et al. 2003). However, not all people with strabismus will have large angles, or deviations that are readily apparent.

Adult strabismus surgery

Given the information presented in previous sections, there are many good reasons to consider strabismus surgery as an adult. In this section, we will describe the benefits of adult strabismus surgery and the risk of developing diplopia.

Surgical realignment of strabismus is reconstructive surgery

Correction of strabismus improves both appearance and function (Beauchamp et al. 2003; Gill and Drummond 1997) and, therefore, surgery should not be considered cosmetic. The term cosmetic implies enhancement of something that is normal. Because a misalignment of the eyes is abnormal, surgery to correct it should be referred to as reconstructive (Hunter 1995) or restorative (Edelman 2010).

Functional benefits of strabismus surgery

Correction of adult strabismus may lead to improvements in fusion (Morris et al. 1993), stereoacuity (Lal and Holmes 2002) and head posture (Gill and Drummond 1997). Binocular summation, the improvement in visual acuity when using both eyes compared to only the better eye, may improve following surgery (Pineles et al. 2015a). Patients with esotropia may benefit from an enlargement of the visual field, although the visual field of patients with exotropia may be reduced (Wortham and Greenwald 1989). Surgery can lead to resolution of social problems and driving difficulties (Beauchamp et al. 2003). Following adult strabismus surgery, complete resolution of symptoms is achieved in 76% of patients with symptoms prior to surgery (Gill and Drummond 1997).

Diplopia is the most common presenting complaint of adults with strabismus (Beauchamp et al. 2003). A meta-analysis carried out by the American Academy of Ophthalmology in 2004 (Mills et al. 2004), which included data from 49 reports describing outcomes for adults undergoing strabismus surgery, found that surgery resolved diplopia in 527 of 688 patients (72%) who had diplopia prior to surgery.

The vast majority of adults undergoing strabismus surgery obtain peripheral binocularity, which is linked to the subsequent stability of ocular alignment immediately following surgery, irrespective of the duration of the strabismus or the depth of any amblyopia (Kushner and Morton 1992). Following surgery to correct chronic acquired strabismus in adults, two-thirds of all patients regain some stereoacuity and nearly half regain stereoacuity of 60 seconds of arc or better (Lal and Holmes 2002).

There is growing interest in new computer-based methods for improving vision in adults with amblyopia (Hussain et al. 2014; To et al. 2011; Vedamurthy et al. 2016). A range of experience-dependent improvements in visual function have been demonstrated in laboratory studies, including improvements in stereoacuity (Astle et al. 2011; Ding and Levi 2011). Clinical trials are currently being carried out to determine the effectiveness of the new computer-based methods. If the results from clinical trials support the use of these approaches, it may be possible to offer the prospect of good binocular vision to patients with amblyopia that persists following surgical correction of strabismus.

Psychosocial benefits of strabismus surgery

The majority of adults with strabismus seek treatment to improve their appearance, rather than to improve visual function (Horgan et al. 1998; Menon et al. 2002). Adult strabismus surgery leads to psychosocial improvements, most probably due to objective and subjective improvements in appearance, ie how people with strabismus perceive themselves and how others view them once the misalignment is corrected.

Menon et al. (2002) investigated the effects of strabismus surgery in patients aged 15–25 years. Prior to surgery, the majority of patients reported personal issues because of their strabismus and problems with their social life. After surgery, 95% of patients reported an improvement in self-esteem and self-confidence. Related to this, Burke and colleagues (1997) investigated the effect of strabismus surgery on 31 adults who underwent horizontal strabismus surgery. Patients perceived that their surgery improved psychosocial function with regard to 15 investigated personality traits. Participants reported improvements in confidence, attractiveness, self-esteem and the ability to interact with people of the opposite sex. Female patients and patients with esotropia reported the greatest benefit from surgery (even though the pre- and postoperative angles of deviation were similar between convergent and divergent deviations). There was no relationship between improvements and the age of the patients. This is important, because it suggests there are benefits to adult surgery regardless of the age of the patient.

Adults with strabismus and poor vision in each eye, who as a result cannot see their own strabismus, have also reported benefits from strabismus surgery. An analysis of medical records of patients with poor vision bilaterally indicates that patients experience improvements in happiness, confidence and self-esteem following treatment to correct strabismus (Dawson et al. 2013).

Risk of diplopia

Eye care practitioners may be reluctant to recommend restorative surgery to adults with strabismus due to fear of the risks of intractable diplopia. Intractable diplopia can clearly cause significant distress (Gruzensky and Palmer 1988) and may require the occlusion of vision in one eye. This can be achieved using a Chavasse lens, occlusive contact lens, occlusive intraocular lens, Botulinum toxin to induce ptosis, or by tattooing the cornea (Dawson et al. 2009; Stone et al. 2008).

The probability of postoperative diplopia depends critically upon the quality of postoperative alignment. New surgical techniques, such as adjustable sutures, which allow adjustment of the angle of deviation during or after surgery, lead to better alignment in adults, particularly for reoperation on childhood-onset strabismus (Zhang et al. 2012). Results from a randomised controlled trial (Carruthers et al. 1990) indicate that satisfactory alignment, defined as a deviation of less than 10ΔD 6 months after surgery, is achieved in around 80% of adults undergoing adjustable suture strabismus surgery after a single operation. There was no difference in response to treatment in patients with large- or small-angle deviations.

The likelihood of postoperative diplopia can be assessed by using a prism to neutralise the angle of deviation and finding the repeatable misalignment range over which any diplopia is noticed: patients who do not notice double vision when undergoing this test are unlikely to go on to experience intractable diplopia after satisfactory alignment surgery (Kushner 2002). Botulinum toxin injections may also allow the risk of postoperative diplopia to be assessed, as well as offering an alternative method of correction to strabismus surgery.

Kushner (2002) reviewed 424 records of adults who underwent strabismus surgery that resulted in satisfactory alignment and who had no diplopia prior to surgery. Following surgery, fewer than 1% of patients had intractable diplopia. Fewer than 10% of patients had temporary diplopia, which resolved in all patients 6 weeks after surgery. In addition, the duration of the deviation did not affect the likelihood of developing diplopia following surgery. Therefore, although there are risks associated with strabismus surgery, intractable diplopia is a relatively rare outcome.

Is strabismus surgery cost-effective?

The value of medical interventions can be economically evaluated using a cost-utility analysis. Value is often quantified as the cost (in monetary terms) per quality-adjusted life years (QALYs). QALYs take into account quality of life and life expectancy. The lower the cost in $/QALY, the more cost-effective the intervention. Beauchamp et al. (2006) carried out a quantitative assessment of the value of strabismus surgery in the United States. They found that strabismus surgery in adults is highly cost-effective, with a more cost-effective health value ($1632/QALY) than amblyopia therapy ($2395/QALY; Membreno et al. 2002) and adult cataract surgery ($2093/QALY for the first eye; Busbee et al. 2002).

Is adult strabismus surgery becoming more frequent?

We wondered whether the increase in evidence for the functional and psychosocial benefits of adult strabismus surgery has been associated with an increase in adult strabismus operations. To investigate this we carried out a retrospective study analysing Hospital Episode Statistics and found that, even when changes in the population are taken into account, adult strabismus surgery has become more frequent over the last 15 years. In contrast, the number of strabismus operations carried out on children decreased over the same period (Astle et al. 2016). Figure 3 shows the change in number of strabismus operations carried out on patients younger than 15 years of age and patients aged 15 years and older. An increase in the number of adults with strabismus and better access to information on adult strabismus on the internet and in the scientific and medical literature may have contributed to the increase in adult strabismus operations. Optometrists are ideally placed to provide information to patients with strabismus who may benefit from strabismus surgery and to refer patients to be considered for surgery.

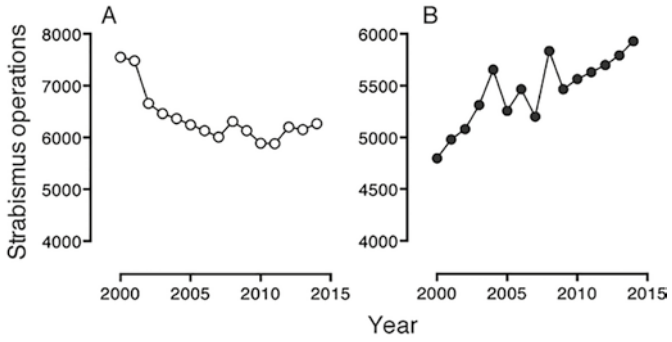

Figure 3. Strabismus operations in England between 2001 and 2015 carried out on patients aged (A) 0–14 years and (B) 15 years or older. (Adapted from Astle et al. (2016).)

Conclusion

Adults with strabismus experience many debilitating consequences: communication, education, employment, personal relationships, mental health and quality of life may all be affected. Because of this, surgical procedures to correct ocular misalignment should not be considered cosmetic but rather reconstructive. Strabismus surgery reduces the visual and psychosocial consequences of strabismus in many patients and is increasing in frequency in adults. Patients should be made aware that surgery to correct strabismus in adulthood is possible and carries a low risk of complications. Those interested in undergoing treatment should be referred to an ophthalmologist specialising in strabismus surgery to discuss the potential benefits and risks involved, irrespective of their age or onset of strabismus.

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Summary

The purpose of this article is to inform the reader of the potential psychosocial consequences associated with strabismus. This information will enhance the understanding of the benefits of surgery, even in adulthood.

References

Adams G G, Karas M P (1999) Effect of amblyopia on employment prospects. *Br J Ophthalmol* **83**, 380

Akay A P, Cakaloz B, Berk A T et al. (2005) Psychosocial aspects of mothers of children with strabismus. *J Am Assoc Pediatr Ophthalmol Strabism* **9**, 268–73

Astle A T, McGraw P V, Webb B S (2011) Recovery of stereo acuity in adults with amblyopia. *BMJ Case Rep* 10.1136/bcr.07.2010.3143

Astle A T, Foulsham T, Foss A J et al. (2016) Is the frequency of adult strabismus surgery increasing? *Ophthalmol Physiol Optics* **36**, 487–93

Babar S, Khare G D, Vaswani R S et al. (2010) Eye dominance and the mechanisms of eye contact. *J AAPOS* **14**, 52–7

Beauchamp G R, Black B C, Coats D K et al. (2003) The management of strabismus in adults – I. Clinical characteristics and treatment. *J Am Assoc Pediatr Ophthalmol Strabism* **7**, 233–40

Beauchamp G R, Felius J, Stager D R Sr et al. (2005) The utility of strabismus in adults. *Trans Am Ophthalmol Soc* **103**, 164

Beauchamp C L, Beauchamp G R, Stager D R Sr et al. (2006) The cost utility of strabismus surgery in adults. *J AAPOS* **10**, 394–9

Bez Y, Coskun E, Erol K et al. (2009) Adult strabismus and social phobia: a case-controlled study. *J AAPOS* **13**, 249–52

Burke J P, Leach C M, Davis H (1997) Psychosocial implications of strabismus surgery in adults. *J Pediatr Ophthalmol Strabism* **34**, 159–64

Busbee B G, Brown M M, Brown G C et al. (2002) Incremental cost-effectiveness of initial cataract surgery. *Ophthalmology* **109**, 606–12

Carruthers J D, Kennedy R A, Bagaric D (1990) Botulinum vs adjustable suture surgery in the treatment of horizontal misalignment in adult patients lacking fusion. *Arch Ophthalmol* **108**, 1432–5

Chan K W, Deng L, Weissberg E M (2016) Detection of strabismus by non-health care professionals in an ethnically diverse set of images. *JAMA Ophthalmol* **134**, 30–6

Chang M Y, Velez F G, Demer J L et al. (2015) Quality of life in adults with strabismus. *Am J Ophthalmol* **159**, 539–44. e532

- Chia A, Roy L, Seenyen L (2007) Comitant horizontal strabismus: an Asian perspective. *Br J Ophthalmol* **91**, 1337–40
- Chua B, Mitchell P (2004) Consequences of amblyopia on education, occupation, and long term vision loss. *Br J Ophthalmol* **88**, 1119–21
- Coats D K, Paysse E A, Towler A J et al. (2000) Impact of large angle horizontal strabismus on ability to obtain employment. *Ophthalmology* **107**, 402–5
- Coats D K, Stager D R, Beauchamp G R et al. (2005) Reasons for delay of surgical intervention in adult strabismus. *Arch Ophthalmol* **123**, 497–9
- Dawson E, Maino A, Lee J (2009) A unique use for a corneal tattoo. *Strabismus* **17**, 98–100
- Dawson E, Leung H, Webster A et al. (2013) Beneficial effect of treatment for strabismus in patients with bilaterally poor vision, who cannot see their strabismus. *Strabismus* **21**, 33–6
- Ding J, Levi D M (2011) Recovery of stereopsis through perceptual learning in human adults with abnormal binocular vision. *Proc Natl Acad Sci* **108**, E733–41
- Durnian J M, Owen M E, Marsh I B (2009) The psychosocial aspects of strabismus: correlation between the AS-20 and DAS59 quality-of-life questionnaires. *J Am Assoc Pediatr Ophthalmol Strabism* **13**, 477–80
- Durnian J M, Owen M E, Baddon A C et al. (2010) The psychosocial effects of strabismus: effect of patient demographics on the AS-20 score. *J Am Assoc Pediatr Ophthalmol Strabism* **14**, 469–71
- Durnian J M, Noonan C P, Marsh I B (2011) The psychosocial effects of adult strabismus: a review. *Br J Ophthalmol* **95**, 450–3
- Edelman P M (2010) Functional benefits of adult strabismus surgery. *Am Orthoptic J* **60**, 43–7
- Foulsham T (2015) Eye movements and their functions in everyday tasks. *Eye (Lond)* **29**, 196–9
- Gill M, Drummond G (1997) Indications and outcomes of strabismus repair in visually mature patients. *Can J Ophthalmol/J Can d'ophtalmol* **32**, 436–40
- Glasman P, Cheeseman R, Wong V et al. (2013) Improvement in patients' quality-of-life following strabismus surgery: evaluation of postoperative outcomes using the Adult Strabismus 20 (AS-20) score. *Eye (Lond)* **27**, 1249–53
- Goff M J, Suhr A W, Ward J A et al. (2006) Effect of adult strabismus on ratings of official U.S. Army photographs. *J AAPOS* **10**, 400–3
- Grant S, Moseley M J (2011) Amblyopia and real-world visuomotor tasks. *Strabismus* **19**, 119–28
- Gruzensky W D, Palmer E A (1988) Intractable diplopia: a clinical perspective. *Graefe's Arch Clin Exp Ophthalmol* **226**, 187–92
- Hatt S R, Leske D A, Kirgis P A et al. (2007) The effects of strabismus on quality of life in adults. *Am J Ophthalmol* **144**, 643–7
- Hatt S R, Leske D A, Bradley E A et al. (2009) Development of a quality-of-life questionnaire for adults with strabismus. *Ophthalmology* **116**, 139–44. e135
- Haverkamp A (2007). *Gray Mouse Lemur.* CC BY 2.0. Retrieved from https://www.flickr.com/photos/46956042@N00/818248941 (accessed 11 July 2016)
- Ho S, Foulsham T, Kingstone A (2015) Speaking and listening with the eyes: gaze signaling during dyadic interactions. *PloS One* **10**, e0136905
- Horgan S E, Lee J P, Bunce C (1998) The long-term use of botulinum toxin for adult strabismus. *J Pediatr Ophthalmol Strabism* **35**, 9
- Hunter D G (1995) Benefits of strabismus surgery in patients with one blind eye. *Arch Ophthalmol* **113**, 404
- Hussain Z, Astle A T, Webb B S et al. (2014) The challenges of developing a contrast-based video game for treatment of amblyopia. *Front Psychol* **5**, 1210
- Ismail B, Cantor-Graae E, McNeil T F (1998) Minor physical anomalies in schizophrenic patients and their siblings. *Am J Psychiatry* **155**, 1695–702
- Jackson S, Harrad R A, Morris M et al. (2006) The psychosocial benefits of corrective surgery for adults with strabismus. *Br J Ophthalmol* **90**, 883–8
- Kleinke C L (1986) Gaze and eye contact: a research review. *Psychol Bull* **100**, 78
- Kobayashi H, Kohshima S (1997) Unique morphology of the human eye. *Nature* **387**, 767–8
- Kobayashi H, Kohshima S (2001) Unique morphology of the human eye and its adaptive meaning: comparative studies on external morphology of the primate eye. *J Hum Evolution* **40**, 419–35
- Kushner B J (2001) Recently acquired diplopia in adults with long-standing strabismus. *Arch Ophthalmol* **119**, 1795–801
- Kushner B J (2002) Intractable diplopia after strabismus surgery in adults. *Arch Ophthalmol* **120**, 1498–504
- Kushner B J, Morton G V (1992) Postoperative binocularity in adults with longstanding strabismus. *Ophthalmology* **99**, 316–19
- Lal G, Holmes J M (2002) Postoperative stereoacuity following realignment for chronic acquired strabismus in adults. *J Am Assoc Pediatr Ophthalmol Strabism* **6**, 233–7
- Larson S A, Keech R V, Verdick R E (2003) The threshold for the detection of strabismus. *J Am Assoc Pediatr Ophthalmol Strabism* **7**, 418–22
- Lewis J, Roberson D, Foulsham T (in preparation) The impact of facial abnormalities and their spatial position on perception of cuteness and attractiveness of infant faces.
- McBain H B, Au C K, Hancox J et al. (2014a) The impact of strabismus on quality of life in adults with and without diplopia: a systematic review. *Surv Ophthalmol* **59**, 185–91
- McBain H B, MacKenzie K A, Au C et al. (2014b) Factors associated with quality of life and mood in adults with strabismus. *Br J Ophthalmol* **98**, 550–5

McBain H B, MacKenzie K A, Hancox J et al. (2015) What do patients with strabismus expect post surgery? The development and validation of a questionnaire. *Br J Ophthalmol*, bjophthalmol-2015-307027

McKee S P, Levi D M, Movshon J A (2003) The pattern of visual deficits in amblyopia. *J Vision* **3**, 380–405

Membreno J H, Brown M M, Brown G C et al. (2002) A cost–utility analysis of therapy for amblyopia. *Ophthalmology* **109**, 2265–71

Menon V, Saha J, Tandon R et al. (2002) Study of the psychosocial aspects of strabismus. *J Pediatr Ophthalmol Strabism* **39**, 203–8

Mills M D, Coats D K, Donahue S P et al. (2004) Strabismus surgery for adults: a report by the American Academy of Ophthalmology. *Ophthalmology* **111**, 1255–62

Mohney B G, McKenzie J A, Capo J A et al. (2008) Mental illness in young adults who had strabismus as children. *Pediatrics* **122**, 1033–8

Mojon-Azzi S M, Mojon D S (2009) Strabismus and employment: the opinion of headhunters. *Acta Ophthalmol* **87**, 784–8

Mojon-Azzi S M, Potnik W, Mojon D S (2008) Opinions of dating agents about strabismic subjects' ability to find a partner. *Br J Ophthalmol* **92**, 765–9

Mojon-Azzi S M, Kunz A, Mojon D S (2011) Strabismus and discrimination in children: are children with strabismus invited to fewer birthday parties? *Br J Ophthalmol* **95**, 473–6

Morris R J, Scott W E, Dickey C F (1993) Fusion after surgical alignment of longstanding strabismus in adults. *Ophthalmology* **100**, 135–8

Murray R M, Lewis S W (1987) Is schizophrenia a neurodevelopmental disorder? *Br Med J (Clin Res Ed.)* **295**, 681–2

Nelson B A, Gunton K B, Lasker J N et al. (2008) The psychosocial aspects of strabismus in teenagers and adults and the impact of surgical correction. *J AAPOS* **12**, 72–6 e71

Olitsky S E, Sudesh S, Graziano A et al. (1999) The negative psychosocial impact of strabismus in adults. *J Am Assoc Pediatr Ophthalmol Strabism* **3**, 209–11

Paysse E A, Steele E A, McCreery K M et al. (2001) Age of the emergence of negative attitudes toward strabismus. *J AAPOS* **5**, 361–6

Pineles S L, Demer J L, Isenberg S J et al. (2015a) Improvement in binocular summation after strabismus surgery. *JAMA Ophthalmol* **133**, 326–32

Pineles S L, Repka M X, Yu F et al. (2015b) Risk of musculoskeletal injuries, fractures, and falls in Medicare beneficiaries with disorders of binocular vision. *JAMA Ophthalmol* **133**, 60–5

Rahi J S, Cumberland P M, Peckham C S (2006) Does amblyopia affect educational, health, and social outcomes? Findings from 1958 British birth cohort. *BMJ* **332**, 820–5

Righi S, Boffano P, Guglielmi V et al. (2014) Diplopia and driving: a problematic issue. *J Cranio-Maxillofac Surg* **42**, 1329–33

Ritchie A, Colapinto P, Jain S (2013) The psychological impact of strabismus: does the angle really matter? *Strabismus* **21**, 203–8

Satterfield D, Keltner J L, Morrison T L (1993) Psychosocial aspects of strabismus study. *Arch Ophthalmol* **111**, 1100–5

Schalock R L (2004) The concept of quality of life: what we know and do not know. *J Intellect Disabil Res* **48**, 203–16

Sim B, Yap G H, Chia A (2014) Functional and psychosocial impact of strabismus on Singaporean children. *J AAPOS* **18**, 178–82

Stidwill D (1997) Epidemiology of strabismus. *Ophthalmol Physiol Optics* **17**, 536–9

Stone N, Somner J, Jay J (2008) Intractable diplopia: a new indication for corneal tattooing. *Br J Ophthalmol* **92**, 1445

To L, Thompson B, Blum J R et al. (2011) A game platform for treatment of amblyopia. *IEEE Trans Neural Syst Rehabil Eng* **19**, 280–9

Toyota T, Yoshitsugu K, Ebihara M et al. (2004) Association between schizophrenia with ocular misalignment and polyalanine length variation in PMX2B. *Hum Mol Genet* **13**, 551–61

Uretmen O, Egrilmez S, Kose S et al. (2003) Negative social bias against children with strabismus. *Acta Ophthalmol Scand* **81**, 138–42

Vedamurthy I, Knill D C, Huang S J et al. (2016) Recovering stereo vision by squashing virtual bugs in a virtual reality environment. Phil Trans R Soc B 371, 20150264

Wortham E V, Greenwald M J (1989) Expanded binocular peripheral visual fields following surgery for esotropia. *J Pediatr Ophthalmol Strabism* **26**, 109–12

Zhang M S, Hutchinson A K, Drack A V et al. (2012) Improved ocular alignment with adjustable sutures in adults undergoing strabismus surgery. *Ophthalmology* **119**, 396–402

CET multiple choice questions

This article has been approved for one non-interactive point under the GOC's Enhanced CET Scheme. The reference and relevant competencies are stated at the head of the article. To gain your point visit the College's website www.college-optometrists.org/oip and complete the multiple choice questions online. The deadline for completion is 31 October 2017. Please note that the answers that you will find online are not presented in the same order as in the questions below, to comply with GOC requirements.

1. Which of the following would not cause adult-onset strabismus?

- Third cranial nerve palsy
- Thyroid disease
- Stroke
- Increase in hyperopia

2. Approximately how many headhunters felt that people with large-angle strabismus would have more difficulty finding employment?

- 55%
- 65%
- 75%
- 85%

3. Which one of the following is most important in determining whether the patient is likely to have intractable diplopia following surgery?

- The patient's age
- The angle of deviation preoperatively
- The quality of alignment postoperatively
- The surgical technique used

4. At what age do children first develop negative feelings towards a toy doll with strabismus?

- 4½
- 4¾
- 5½
- 5¾

5. Which one of the following statements is true?

- Esotropia is more common than exotropia in East Asian people
- Exotropia is more difficult to detect than esotropia in black people
- Esotropia is easier to detect than exotropia in East Asian people
- Exotropia is more common than esotropia in white people

6. Approximately what proportion of adults undergoing surgery to correct chronic acquired strabismus regain stereo acuity of 60 seconds of arc or better?

- 40%
- 50%
- 60%
- 70%

CPD exercise

After reading this article, can you identify areas in which your knowledge of strabismus and strabismus surgery has been enhanced?

How do you feel you can use this knowledge to offer better patient advice?

Are there any areas you still feel you need to study and how might you do this?

Which areas outlined in this article would you benefit from reading in more depth, and why?