Strabismus Surgery for Adults

A Report by the American Academy of Ophthalmology

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Objective: To describe the effectiveness and safety of surgical treatment of adult patients with strabismus, and to review the reported functional benefits and complications of strabismus surgery for adults.

Methods: A literature search was conducted in September 2001. It was repeated and updated in April 2003, with retrieval of relevant citations. Panel members reviewed the articles and rated them according to their relevance to the topic and methodology.

Results: The literature search identified 49 reports that describe the surgical treatment of strabismus in adult patients and meet predetermined review criteria. Of these reports, 2 were of randomized controlled trials, and 1 addressed the primary objective of this review. In this randomized study of adults with strabismus, direct comparison of surgical correction with botulinum toxin A chemodenervation indicated that surgical treatment was superior to botulinum toxin A in realigning the eyes (76.9% vs. 29.4%, $P = 0.027$). Several large case series of adults with strabismus (level III evidence) with successful surgical realignment rates of 68% to 85% have been reported. Functional benefits of surgical treatment are reported in many patients. These include elimination of diplopia, development of binocular fusion, expansion of binocular visual fields, and improvement of head position. Surgical complications, including new, postoperative diplopia (1%–14%) or scleral perforation (0.8%–1.8%), occur in a minority of patients. Unplanned reoperations (subsequent strabismus procedures that were not anticipated as part of a staged treatment) were needed in up to 21% of patients in large case series of comitant strabismus, and in up to 50% of patients with thyroid ophthalmopathy.

Conclusions: Despite the paucity of level I evidence from randomized controlled trials, the existing literature suggests that surgical treatment of adults with strabismus is safe and effective in improving ocular alignment. In many cases it improves visual function, based largely on level III evidence. Risks include unplanned reoperation, postoperative diplopia, and scleral perforation. Additional level I studies of surgical treatment of adult patients would help to document the effectiveness and substantiate the safety of this treatment. *Ophthalmology 2004; 111:1255–1262 © 2004 by the American Academy of Ophthalmology.*

Introduction

The American Academy of Ophthalmology prepares Ophthalmic Technology Assessments to evaluate new and existing procedures, drugs, and diagnostic and screening tests. The goal of an assessment is to review systematically the available research for clinical efficacy, effectiveness, and safety. After appropriate review by members of the Ophthalmic Technology Assessment Committee, other Academy committees, relevant subspecialty societies, and legal counsel, assessments are submitted to the Academy's Board of Trustees for consideration as official Academy statements.

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Background

Strabismus, or misalignment of the eyes, is a condition that occurs at all ages. In children, strabismus is frequently associated with amblyopia and lack of binocular fusion. Surgical treatment of childhood strabismus is frequently recommended to restore normal ocular alignment and facilitate development of binocularity.

Adults may have strabismus beginning in childhood (with or without earlier treatment), or may have acquired strabismus related to acquired cranial nerve palsies, orbital trauma, thyroid ophthalmopathy, or other orbital or neurologic diseases, or secondary to other ophthalmic procedures. Unlike young children with strabismus, adults may have had normal binocularity before the onset of strabismus, and they may have diplopia, visual confusion, or other symptoms related to strabismus. Additionally, the initial symptoms of adults with strabismus may be abnormal head posture, abnormal facial appearance due to ocular misalignment, or asthenopia related to poorly controlled intermittent strabismus.

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In addition to anatomical realignment of the eyes, surgical treatment of adult patients may have benefits different from or in addition to those expected after successful childhood surgery. Benefits of surgery for adults include improved diplopia; improved binocularity; expanded binocular visual fields; improved head position; and improved self-esteem, social interactions, and ability to communicate with others.

Anesthetic considerations and the potential for postoperative adjustment of sutures are somewhat dependent on the age of the patient and ability to cooperate, but general surgical techniques for strabismus are similar in patients of all ages. Surgical complications may differ between surgery performed during early childhood and surgery performed on visually mature adult strabismus patients, however, because of differences in binocularity and sensory adaptations to abnormal eye alignment. Postoperative diplopia may occur in younger patients, but this complication is most likely to occur and most likely to be bothersome in visually mature patients.

Description of the Procedure

For the purposes of this assessment, strabismus surgery is defined as incisional surgical procedures performed on the extraocular muscles to treat strabismus. Botulinum toxin A chemodenervation and optical and orthoptic treatments were considered to be nonsurgical and are not the primary subject of this assessment.

Resource Requirements

Economic analysis was not included in this evaluation. Strabismus surgery is generally performed in an outpatient setting, using either general or local anesthesia. The surgical treatment of adults with strabismus also requires ophthalmic surgeons trained in strabismus surgery and ambulatory surgical facilities that have anesthesia services available. Operating time typically lasts 30 to 90 minutes. Surgical management typically requires 2 to 4 additional postoperative outpatient clinical examinations in addition to the surgical encounter. Most adults are able to return to unrestricted occupational function within 2 to 7 days of surgery.

Questions for Assessment

The focus of this assessment is to address the following questions:

- Does strabismus surgery in adults provide clinically significant benefit?
- What are the reported complications of strabismus surgery in adults?

Description of Evidence

The literature search was conducted in September 2001 in MEDLINE for 1986 to 2001 and was limited to articles describing human subjects and published in English with abstracts. The Cochrane Library of clinical trials was also investigated. The MeSH major topic terms *strabismus* or *esotropia* or *exotropia* were used with the subheading of *surgery* for the age groups adolescent (13–18 years) and adult (≥19 years). This search identified 432 citations. Abstracts of meeting presentations were not subject to peer review and were not included in the analysis.

The authors reviewed the abstracts retrieved in the literature search and selected 93 articles of possible clinical relevance for review. Inclusion criteria for studies were that participants be 13 years or older and have strabismus, that the intervention of the incisional surgical procedure be performed on the extraocular muscles, and that outcome measures of objective and subjective functional vision assessments and of subjective self-image and cosmesis be reported. Single-case reports and series of <4 patients were excluded. All study designs were included. The authors read these articles and selected 41 that met the inclusion criteria for review by the panel methodologist, who assigned one of the following ratings of strength of evidence to each of the selected articles. A level I rating was assigned to properly conducted, well-designed, randomized clinical trials; a level II rating was assigned to well-designed cohort and case–control studies; and a level III rating was assigned to case series.

The literature search was repeated in April 2003 for publications from 2001 to April 2003, using identical search parameters. In a similar way, abstracts from 53 publications were reviewed, and 15 were identified as potentially meeting the established criteria. Of those 15 publications reviewed in detail, 9 met the study criteria. Altogether, 108 publications were reviewed in detail over the 2 search periods; 49 met the study criteria and were included in this analysis.

Published Results

Benefits

Ocular Alignment. The primary objective of most strabismus surgery in both children and adults is to normalize the ocular alignment, and this is the most frequent outcome measure reported in the 49 publications reviewed in this study. Surgery is capable of improving ocular alignment in the majority of patients reported in all series, even those with complex incomitant strabismus.

In the only level I randomized controlled study of surgical treatment for adult strabismus, Carruthers et al[1] defined a successful outcome as a final deviation of <10 prism diopters at least 6 months after treatment. In the surgical treatment group, 10 of 13 patients (76.9%) had a successful outcome; botulinum-treated patients had a success rate of 29.4% ($P = 0.027$).[1] In the 24 case series (all except Carruthers et al's were level III evidence retrospective case series) with reports of detailed outcomes, 82% to 100% of patients showed improved alignment postoperatively, and 25% to 100% of patients met commonly reported objective criteria of ≤12–prism diopter residual horizontal and ≤4–

prism diopter vertical heterotropia (Table 1). Several of these series describe patients with complicated strabismus who would be expected to have less favorable postoperative outcomes, such as patients with coexisting thyroid ophthalmopathy[2–7] and patients with incomitant vertical deviations.[8–12]

Reports of 3 large case series (level III evidence) have been published describing surgical results in more than 250 consecutive adult patients each. In these large series, 68% to 85% of patients met their authors' definition of successful realignment, which varied somewhat in each study.[13–15] Larger than standard amounts of surgery and procedures other than standard rectus muscle resection or recession (including marginal myotomy and adjustable suture techniques) are reported to have similar results.[11,12,16–20]

Diplopia. Eighteen of the reports (level III evidence) that were reviewed described the preoperative and postoperative sensory status of the patients. Of the 688 total combined patients who were reported to have preoperative diplopia, 527 (72%) had no diplopia postoperatively (Table 2). Individual reports calculated that 45% to 100% of patients who had preoperative diplopia were cured (Table 2).

Binocularity. Postoperative binocularity was the focus of reports by Ball et al,[21] Kushner,[22] Lal and Holmes,[23] and Morris et al.[24] Of the 324 consecutive adult patients studied in Kushner's series, 70% regained binocularity, as measured by the Bagolini lens test (level III evidence).[22] When all of the series that reported binocular status before and after surgery were combined, 979 of 1488 (66%) patients demonstrated restoration of sensory binocular fusion after strabismus surgery. A variety of methods, including Bagolini lenses and Titmus, Lang, and Worth binocular tests, were used to measure binocular status. Regained binocularity rates of 30% to 100% were described in individual reports (Table 2).

Sensory fusion after strabismus correction is not limited to patients with strabismus acquired in adulthood. Kushner[22] and Scott et al[14] reported that 23% to 75% of patients with known infantile onset of esotropia developed binocular fusion after realignment, even after many years with strabismus and amblyopia (level III evidence). Scott et al[14] reported that 44% of patients with onset of strabismus before visual maturity and 81% of those with onset after visual maturity developed measurable stereopsis, as measured by the Titmus test, or binocularity, as measured by the Worth test, after surgical strabismus correction in adulthood.

Binocular Visual Fields. The binocular visual field is reduced in patients with esotropia due to the ocular misalignment. Kouri et al,[11] Kushner,[25] and Wortham and Greenwald[26] prospectively studied strabismic patients before and after surgical correction. Correction of strabismus expanded the binocular visual field in 71 of 77 combined patients from these reports (92%), which included patients with longstanding vertical and horizontal strabismus and patients with amblyopia (level III evidence).

Head Position. Torticollis, or abnormal head position, is a frequent symptom in adult strabismus patients with incomitant strabismus and diplopia. Morad et al,[27] in a retrospective series of cases of superior oblique palsy, and Wallace and von Noorden,[28] in a retrospective series of cases of absent superior oblique tendon, reported improvement of head position in a combined total of 22 of 26 patients (85%) after surgery (level III evidence).

Subjective Outcomes. Subjective outcomes from the patient's perspective, such as improved social interaction, self-image, appearance, and communication, are difficult to measure, but they are important potential results of treating disfiguring strabismus in adults. Burke et al[29] documented improved psychosocial functioning in adult patients after strabismus surgery (level III evidence). In a study that did not meet the criteria of this report for interventional studies, Kraft[30] has described the usefulness of psychometric testing to provide objective measures of improvement after strabismus surgery. Menon et al[31] documented negative psychosocial effects of strabismus in a series of 40 adolescents and young adults in India and described improvements in self-esteem and social relationships after surgical correction. Olitsky et al[32] demonstrated the negative effect of large-angle horizontal strabismus on personal appearance in a prospective study (level I evidence) that did not meet the interventional criteria for analysis in this report.

Risks

Postoperative Acquired Diplopia. The mature, normal visual system is not easily capable of sensory adaptations to altered binocular alignment such as suppression. Diplopia may occur when strabismus is acquired after normal visual development in adults. Postoperative diplopia may also occur as a complication of strabismus surgery in adults when longstanding sensory adaptations such as suppression are interrupted by surgery.

Kushner[33] described in detail a series of 424 adult patients with strabismus who did not have preoperative diplopia under normal conditions (sensory adaptation). After their strabismus was successfully corrected surgically, 143 patients (34%) experienced temporary diplopia, and 3 (0.8%) developed persistent diplopia that lasted more than 6 weeks after surgery.[33] Scott et al[14] reported postoperative diplopia in 31 of 338 (8%) strabismus surgery patients with sensory adaptation (no preoperative diplopia). Most patients were diplopic due to residual strabismus, and 5 patients (1%) had intractable diplopia.[14] Gill and Drummond[34] described postoperative diplopia in 6 of 137 visually mature patients after strabismus surgery; 4 of these patients (3%) had intractable diplopia. Choi and Rosenbaum[35] reported that 3 of 21 patients (14%) and Kraft et al[36] reported that 1 of 14 (7%) had persistent diplopia after surgery for exotropia. Intractable postoperative diplopia is a rare complication of strabismus correction in patients who did not have preoperative diplopia (level III evidence).

Postoperative Loss of Binocular Fusion. Many adult patients with strabismus have demonstrable sensory fusion with compensatory head position, intermittently manifest deviations, or prism offset of their strabismus. Loss of sensory fusion would be considered a negative outcome from treatment of strabismus in those patients who were capable of fusion preoperatively. None of the reports reviewed discussed the loss of sensory fusional ability as a

Table 1. Postoperative Improvement in Alignment

Level of Evidence	Study	N	Improved Alignment* [N (%)]	Successful Realignment† [N (%)]
I	Carruthers et al (1990)‡	30	12/13 (92)	10/13 (77)
III	Ball et al (1993)§	8	8/8 (100)	8/8 (100)
III	Buckley and Meekins (1988)‖	17	17/17 (100)	15/17 (88)
III	Choi and Rosenbaum (2001)¶	21	21/21 (100)	19/21 (90)
III	Coats et al (1999)#	8	8/8 (100)	7/8 (88)
III	Cruz and Davitt (1999)**	8	8/8 (100)	8/8 (100)
III	Davidson et al (1993)††	6‡‡	6/6 (100)	4/6 (67)
III	de Decker and Baenge (1988)§§	34‡‡	28/34 (82)	NR
III	Felius et al (2001)‖‖	115‡‡	NR	98/115 (85)
III	Flanders and Hastings (1997)¶¶	22	22/22 (100)	18/22 (82)
III	Grin and Nelson (1987)##	16‡‡	16/16 (100)	13/16 (81)
III	Keech and Heckert (1988)***	47	46/47 (98)	38/47 (81)
III	Kraft et al (1995)†††	14‡‡	14/14 (100)	13/14 (93)
III	Kraus and Bullock (1993)‡‡‡	52	50/52 (96)	37/52 (71)
III	Kushner (1994)§§§	37	37/37 (100)	32/37 (86)
III	Livir-Rallatos et al (2002)‖‖‖	63‡‡	63/63 (100)	NR
III	Morad et al (2001)¶¶¶	12	24/24 (100)	24/24 (100)
III	Morris et al (1993)###	24	24/24 (100)	24/24 (100)
III	Munoz and Rosenbaum (1987)****	33	33/33 (100)	NR
III	Paysse et al (2002)††††	10	10/10 (100)	7/10 (70)
III	Wallace et al (1997)‡‡‡‡	4	4/4 (100)	1/4 (25)
III	Wallace and von Noorden (1994)§§§§	9‡‡	9/9 (100)	5/9 (55)
III	Wiggins and Baumgartner (1999)‖‖‖‖	17	4/4 (100)	NR
III	Wortham and Greenwald (1989)¶¶¶¶	10	10/10 (100)	10/10 (100)

NR = not reported.

Reports included are those identified in this assessment in which preoperative and postoperative alignments were reported individually or tabulated using criteria of ≤12 prism diopters residual horizontal and 4 prism diopters vertical residual deviation in primary position at distance and near fixation.

*Defined as a reduction in the quantitative measurement of deviation compared with preoperative measurement.

†Surgical success is defined as prism cover test measurements within 12 prism diopters horizontally and 4 prism diopters vertically at both distance and near testing, or better, if reported by the author.

‡Carruthers JD, Kennedy RA, Bagaric D. Botulinum vs adjustable suture surgery in the treatment of horizontal misalignment in adult patients lacking fusion. Arch Ophthalmol 1990;108:1432–5.

§Ball A, Drummond GT, Pearce WG. Unexpected stereoacuity following surgical correction of long-standing horizontal strabismus. Can J Ophthalmol 1993;28:217–20.

‖Buckley EG, Meekins BB. Fadenoperation for the management of complicated incomitant vertical strabismus. Am J Ophthalmol 1988;105:304–12.

¶Choi DG, Rosenbaum AL. Medial rectus resection(s) with adjustable suture for intermittent exotropia of the convergence insufficiency type. J AAPOS 2001;5:13–7.

#Coats DK, Paysse EA, Plager DA, Wallace DK. Early strabismus surgery for thyroid ophthalmopathy. Ophthalmology 1999;106:324–9.

**Cruz OA, Davitt BV. Bilateral inferior rectus muscle recession for correction of hypotropia in dysthyroid ophthalmopathy. J AAPOS 1999;3:157–9.

††Davidson JL, Rosenbaum AL, McCall LC. Strabismus surgery in patients with myasthenia. J Pediatr Ophthalmol Strabismus 1993;30:292–5.

‡‡Reports in which both child and adult subjects were included. When possible, only adult patients are included from reports with mixed age groups.

§§de Decker W, Baenge JJ. Unilateral medial rectus resection in the treatment of small-angle exodeviation. Graefes Arch Clin Exp Ophthalmol 1988;226:161–4.

‖‖Felius J, Stager DR Jr, Beauchamp GR, Stager DR. Re-recession of the medial rectus muscles in patients with recurrent esotropia. J AAPOS 2001;5:381–7.

¶¶Flanders M, Hastings M. Diagnosis and surgical management of strabismus associated with thyroid-related orbitopathy. J Pediatr Ophthalmol Strabismus 1997;34:333–40.

##Grin TR, Nelson LB. Large unilateral medial rectus recession for the treatment of esotropia. Br J Ophthalmol 1987;71:377–9.

***Keech RV, Heckert RR. Adjustable suture strabismus surgery for acquired vertical deviations. J Pediatr Ophthalmol Strabismus 1988;25:159–63.

†††Kraft SP, Levin AV, Enzenauer RW. Unilateral surgery for exotropia with convergence weakness. J Pediatr Ophthalmol Strabismus 1995;32:183–7.

‡‡‡Kraus DJ, Bullock JD. Treatment of thyroid ocular myopathy with adjustable and nonadjustable suture strabismus surgery. Trans Am Ophthalmol Soc 1993;91:67–79, discussion 79–84.

§§§Kushner BJ. Binocular field expansion in adults after surgery for esotropia. Arch Ophthalmol 1994;112:639–43.

‖‖‖Livir-Rallatos G, Gunton KB, Calhoun JH. Surgical results in large-angle exotropia. J AAPOS 2002;6:77–80.

¶¶¶Morad Y, Weinstock VM, Kraft SP. Outcome of inferior oblique recession with or without vertical rectus recession for unilateral superior oblique paresis. Binocul Vis Strabismus Q 2001;16:23–8.

###Morris RJ, Scott WE, Dickey CF. Fusion after surgical alignment of longstanding strabismus in adults. Ophthalmology 1993;100:135–8.

****Munoz M, Rosenbaum AL. Long-term strabismus complications following retinal detachment surgery. J Pediatr Ophthalmol Strabismus 1987;24:309–14.

††††Paysse EA, Brady McCreery KM, Ross A, Coats DK. Use of augmented rectus muscle transposition surgery for complex strabismus. Ophthalmology 2002;109:1309–14.

‡‡‡‡Wallace DK, Sprunger DT, Helveston EM, Ellis FD. Surgical management of strabismus associated with chronic progressive external ophthalmoplegia. Ophthalmology 1997;104:695–700.

§§§§Wallace DK, von Noorden GK. Clinical characteristics and surgical management of congenital absence of the superior oblique tendon. Am J Ophthalmol 1994;118:63–9.

‖‖‖‖Wiggins RE Jr, Baumgartner S. Diagnosis and management of divergence weakness in adults. Ophthalmology 1999;106:1353–6.

¶¶¶¶Wortham E 5th, Greenwald MJ. Expanded binocular peripheral visual fields following surgery for esotropia. J Pediatr Ophthalmol Strabismus 1989;26:109–12.

Table 2. Preoperative and Postoperative Diplopia, Sensory Binocular Fusion, and Expansion of Visual Fields

Level of Evidence	Study	N	Preoperative Diplopia (N)	Postoperative Diplopia (N)	Diplopia Eliminated (%)	Regained Binocularity* [N (%)]	Expanded Visual Fields [N (%)]
III	Ball et al (1993)[†]	8	NR	NR	NR	8/8 (100)	NR
III	Flanders and Hastings (1997)[‡]	22	22/22	4/22	82	NR	NR
III	Gill and Drummond (1997)[§]	222	85/222	28/85	67	NR	NR
III	Hertle (1998)[‖]	262	81/255	5/81	94	117/255 (46)	
III	Kouri et al (2002)[¶]	32	NR	NR	NR	NR	27/32 (84)
III	Kushner (1994)[#]	37	NR	NR	NR	29/35 (83)	34/35 (97)
III	Kushner (1990)**	324	NR	NR	NR	277/324 (85)	NR
III	Lal and Holmes (2002)[††]	18	NR	NR	NR	12/18 (67)	NR
III	Liao et al (1996)[‡‡]	51	24/24	7/24	71	17/24 (71)	NR
III	Morad et al (2001)[§§]	12	15/24	4/15	73	4/24 (17)	NR
III	Morris et al (1993)[‖‖]	24	NR	NR	NR	24/24 (100)	NR
III	Munoz and Rosenbaum (1987)[¶¶]	33	20/20	9/20	55	NR	NR
III	Paysse et al (2002)[##]	10***	8/10	2/8	75	NR	NR
III	Scott et al (1995)[†††]	892	417/892	95/417	77	488/774 (63)	NR
III	von Noorden et al (1996)[‡‡‡]	11	11/11	6/11	45	NR	NR
III	Wallace et al (1997)[§§§]	4	3/4	1/3	67	NR	NR
III	Wallace and von Noorden (1994)[‖‖‖]	9	2/3	0/2	100	NR	NR
III	Wortham and Greenwald (1989)[¶¶¶]	10	NR	NR	NR	3/10 (30)	10/10 (100)

NR = not reported.
Reports included are those identified in this assessment in which the preoperative and postoperative assessments of diplopia or measurements of binocularity, sensory fusion, and binocular visual fields were reported.
*Tests varied among studies, including Titmus, Bagolini, and Worth duochrome.
[†]Ball A, Drummond GT, Pearce WG. Unexpected stereoacuity following surgical correction of long-standing horizontal strabismus. Can J Ophthalmol 1993;28:217–20.
[‡]Flanders M, Hastings M. Diagnosis and surgical management of strabismus associated with thyroid-related orbitopathy. J Pediatr Ophthalmol Strabismus 1997;34:333–40.
[§]Gill MK, Drummond GT. Indications and outcomes of strabismus repair in visually mature patients. Can J Ophthalmol 1997;32:436–40.
[‖]Hertle RW. Clinical characteristics of surgically treated adult strabismus. J Pediatr Ophthalmol Strabismus 1998;35:138–45.
[¶]Kouri AS, Bessant DA, Adams GG, et al. Quantitative changes in the field of binocular single vision following a fadenoperation to a vertical rectus muscle. J AAPOS 2002;6:294–9.
[#]Kushner BJ. Binocular field expansion in adults after surgery for esotropia. Arch Ophthalmol 1994;112:639–43.
**Kushner BJ. Postoperative binocularity in adults with long standing strabismus. Is surgery cosmetic only? Am Orthopt J 1990;40:64–7.
[††]Lal G, Holmes JM. Postoperative stereoacuity following realignment for chronic acquired strabismus in adults. J AAPOS 2002;6:233–7.
[‡‡]Liao CL, Kao SC, Change TC, Hou PK. Staged operation for Graves' ophthalmopathy. J Formos Med Assoc 1996;95:680–5.
[§§]Morad Y, Weinstock VM, Kraft SP. Outcome of inferior oblique recession with or without vertical rectus recession for unilateral superior oblique paresis. Binocul Vis Strabismus Q 2001;16:23–8.
[‖‖]Morris RJ, Scott WE, Dickey CF. Fusion after surgical alignment of longstanding strabismus in adults. Ophthalmology 1993;100:135–8.
[¶¶]Munoz M, Rosenbaum AL. Long-term strabismus complications following retinal detachment surgery. J Pediatr Ophthalmol Strabismus 1987;24:309–14.
[##]Paysse EA, Brady McCreery KM, Ross A, Coats DK. Use of augmented rectus muscle transposition surgery for complex strabismus. Ophthalmology 2002;109:1309–14.
***Only adult patients in the series are tabulated.
[†††]Scott WE, Kutschke PJ, Lee WR. 20th annual Frank Costenbader Lecture—adult strabismus. J Pediatr Ophthalmol Strabismus 1995;32:348–52.
[‡‡‡]von Noorden GK, Jenkins RH, Chu MW. Horizontal transposition of the vertical rectus muscles for cyclotropia. Am J Ophthalmol 1996;122:325–30.
[§§§]Wallace DK, Sprunger DT, Helveston EM, Ellis FD. Surgical management of strabismus associated with chronic progressive external ophthalmoplegia. Ophthalmology 1997;104:695–700.
[‖‖‖]Wallace DK, von Noorden GK. Clinical characteristics and surgical management of congenital absence of the superior oblique tendon. Am J Ophthalmol 1994;118:63–9.
[¶¶¶]Wortham E 5th, Greenwald MJ. Expanded binocular peripheral visual fields following surgery for esotropia. J Pediatr Ophthalmol Strabismus 1989;26:109–12.

complication of surgery for strabismus. The incidence of this potential complication is unknown.

Unplanned Reoperation. A frequent, although indirect measure of surgical success is the rate of unanticipated reoperation after initial surgical treatment of strabismus. The reports included in this study used variable criteria for reoperation, including the length of the follow-up period and clinical data used to decide on reoperation. In the only level I randomized controlled trial of surgical treatment of strabismus, none of the surgically treated patients and 17% of the patients treated with botulinum toxin A were dissatisfied with their outcome and requested additional treatment. Surgery for strabismus is less likely than treatment with botulinum toxin A to result in retreatment (level I evidence).

Three case series, in which a total of 1515 patients were treated surgically for a heterogeneous group of strabismus diagnoses, reported reoperation rates of 6% to 21% during a postoperative period varying from 6 weeks to more than 10 years (level III evidence).[13,14,37] Many of the other

Table 3. Incidence of Unplanned Reoperation

Level of Evidence	Study	Unplanned Reoperation* [N (%)]
III	Buckley and Meekins (1988)[†]	1/17 (6)
III	Choi and Rosenbaum (2001)[‡]	5/21 (24)
III	Coats et al (1999)[§]	4/8 (50)
III	Cruz and Davitt (1999)[‖]	1/8 (13)
III	Davidson et al (1993)[¶]	1/6 (16)
III	Ehrt et al (2002)[#]	16/234 (7)
III	Felius et al (2001)**	19/59 (32)
III	Flanders and Hastings (1997)[††]	6/22 (27)
III	Gonzalez and Jaros (1988)[‡‡]	3/13 (23)
III	Keech et al (1987)[§§]	19/333 (6)
III	Kraus and Bullock (1993)[‖‖]	15/52 (29)
III	Liao et al (1996)[¶¶]	6/24 (25)
III	McPhee et al (1988)[##]	12/89 (13)
III	Munoz and Rosenbaum (1987)***	2/20 (10)
III	Nguyen et al (2002)[†††]	48/137 (35)
III	Paysse et al (2002)[‡‡‡]	3/18 (17)
III	Pollard and Greenberg (2000)[§§§]	11/66 (17)
III	Scott et al (1995)[‖‖‖]	(12–21)
III	Wallace et al (1997)[¶¶¶]	1/4 (25)
III	Wisnicki et al (1988)[###]	28/290 (10)

Reports included are those identified in this assessment in which subsequent repeat strabismus surgeries were reported, except when surgery was anticipated to be staged in multiple episodes.

*Defined as subsequent episodes of strabismus surgery, except when surgery was anticipated to be staged in multiple episodes.

[†]Buckley EG, Meekins BB. Fadenoperation for the management of complicated incomitant vertical strabismus. Am J Ophthalmol 1988;105:304–12.

[‡]Choi DG, Rosenbaum AL. Medial rectus resection(s) with adjustable suture for intermittent exotropia of the convergence insufficiency type. J AAPOS 2001;5:13–7.

[§]Coats DK, Paysse EA, Plager DA, Wallace DK. Early strabismus surgery for thyroid ophthalmopathy. Ophthalmology 1999;106:324–9.

[‖]Cruz OA, Davitt BV. Bilateral inferior rectus muscle recession for correction of hypotropia in dysthyroid ophthalmopathy. J AAPOS 1999;3:157–9.

[¶]Davidson JL, Rosenbaum AL, McCall LC. Strabismus surgery in patients with myasthenia. J Pediatr Ophthalmol Strabismus 1993;30:292–5.

[#]Ehrt O, Bekl Y, Boergen KP. Effect of inferior oblique recession in strabismus susoadductorius. Strabismus 2002;10:63–8.

**Felius J, Stager DR Jr, Beauchamp GR, Stager DR. Re-recession of the medial rectus muscles in patients with recurrent esotropia. J AAPOS 2001;5:381–7.

[††]Flanders M, Hastings M. Diagnosis and surgical management of strabismus associated with thyroid-related orbitopathy. J Pediatr Ophthalmol Strabismus 1997;34:333–40.

[‡‡]Gonzalez C, Jaros PA. Strabismus surgery on the nonamblyopic eye. Graefes Arch Clin Exp Ophthalmol 1988;226:304–8.

[§§]Keech RV, Scott WE, Christensen LE. Adjustable suture strabismus surgery. J Pediatr Ophthalmol Strabismus 1987;24:97–102.

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smaller series reviewed, which included cases of thyroid ophthalmopathy, incomitant strabismus, and other more complex forms of strabismus, reported reoperation rates of up to 50% (Table 3).

Other Surgical Complications. Intraoperative and early postoperative surgical complications have been reported in adult strabismus cases. In a level I randomized controlled trial of anesthesia techniques for adult strabismus surgery, Tramer et al[38] reported a 13% to 20% risk of intraoperative oculocardiac reflex (acute heart rate decrease of ≥20% during extraocular muscle traction) and a 21% to 31% risk of postoperative nausea or vomiting. The incidence of these complications was not influenced by the anesthesia protocols used. Hertle[15] reported that intraoperative oculocardiac reflex occurred in 30% of patients (level III evidence). No patients in either of these studies had any permanent or prolonged sequelae from these transient intraoperative events.

Noel et al[39] reported inadvertent scleral perforation with intraocular injury (subretinal or choroidal hemorrhage, retinal perforation) after strabismus surgery in 14 of 765 (1.8%) consecutive children examined prospectively after strabismus surgery. Although this study was in patients up to the age of 18 years, the similar technique suggests that the incidence of inadvertent scleral perforation may be similar in adult patients. Hertle[15] reported 2 perforations in 262 cases (0.8%), although patients were not examined prospectively for this complication.

Intraoperative muscle laceration (pulled-in-two syndrome) was reported in 1 case (0.5%) by Hertle.[15] Postoperative slipped muscle was reported in 1 case (0.5%) by Hertle[15] and in 1 case (0.3%) by Keech et al.[13] Hyphema was reported in 1 case (0.5%) by Hertle.[15]

Postoperative infections are rarely reported. There were no reported cases of endophthalmitis among the reports reviewed. Two superficial infections (0.8%) were reported by Hertle.[15] (Endophthalmitis has been described after strabismus surgery in adults. These reports did not meet the criteria for this study, and are not included in this review.)

Other unusual complications that were reported included lower eyelid retraction in 16 of 19 patients (84%) after inferior rectus recession for thyroid ophthalmopathy[5] and sterile inflammation in 3 of 66 patients (5%) with superior oblique tendon spacers.[40] Risks specific to surgery on the nonamblyopic eye in patients with monocular vision impairment, including potential loss of vision, have not been extensively studied.[41,42] Anterior segment ischemia, a rare complication of strabismus surgery in adults, was not reported in any of the publications reviewed for this study.

Conclusions

A single level I randomized clinical trial has been performed to evaluate the clinical benefit of surgery for strabismus in adults. Carruthers et al[1] reported that surgery was effective when compared with botulinum toxin A injection.

Analysis of the other reports available (level III evidence) suggests that surgical treatment of strabismus in adult patients is safe and effective. Surgery is capable of realigning the eyes with a high rate of success. In the largest case series, 68% to 85% of patients were treated successfully by the authors' definitions.[13–15] Reported clinical benefits of this realignment include elimination of preoperative diplopia, re-establishment of binocular fusion, expansion of visual fields, improvement of head posture, and improvement of psychosocial self-assessment.

Strabismus surgery has long-term risks, including postoperative acquired diplopia, loss of binocular fusion, and the need for unplanned reoperation, in addition to the known perioperative risks related to deep scleral suture passes, lost or slipped muscle, postoperative infection, inflammation, and anterior segment ischemia. Surgeons and adult patients, particularly those with thyroid ophthalmopathy, who are considering surgical treatment of strabismus should be aware of the frequency of unanticipated reoperation, primarily due to residual postoperative strabismus.

Future Research

Most of the published reports on the surgical treatment of strabismus in adults are nonrandomized case series. Case series may not be representative of the condition and may not accurately estimate the utility of surgical treatment. Additional level I randomized controlled trials that compare surgical treatment with nonsurgical optical, orthoptic, and botulinum toxin A denervation treatment of adult strabismus should be planned to study the clinical benefits as well as the risks of strabismus surgery in adults. Controlled outcome studies could be designed to measure the benefit from the patient's perspective, which would be more likely to reflect the comprehensive improvement in visual function, social interactions, and self-esteem from this treatment. Prospective nonrandomized studies of surgical outcomes using standardized parameters, including but not limited to prism measurements, and including sensory measurements of binocular fusion and binocular visual fields, will also help to define the indications, expected outcomes, and measurable benefits of surgical strabismus correction in the future.

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