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Comparing outcome criteria performance in adult strabismus surgery

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Abstract

Purpose—To evaluate the performance of motor, diplopia and health-related quality of life (HRQOL) criteria when analyzing outcomes in adult strabismus surgery.

Design—Cohort study

Participants—159 adults undergoing 171 strabismus surgeries

Methods—All patients underwent clinical assessment preoperatively and 6-weeks postoperatively, including completion of Adult Strabismus-20 (AS-20) HRQOL questionnaires. Preoperatively, strabismus was classified as either diplopic (n=117), non-diplopic (n=38) or atypical diplopic (n=16). To assess performance of motor, diplopia and HRQOL criterion, definitions of success were agreed a priori and applied separately, and in combinations. For success: 1) Motor criteria: <10 prism diopters by simultaneous prism cover test); 2) Diplopia criteria: none or only rare in primary distance and for reading; 3) HRQOL criteria: exceeding previously reported 95% limits of agreement.

Main outcome measures—Surgical success rate when applying motor, diplopia, and HRQOL criteria alone and in combinations.

Results—Overall, success rates were 90% for motor criteria, 74% for diplopia criteria and 60% for HRQOL criteria. Combining criteria, the highest success rate was for motor and diplopia criteria (67%) and the lowest success rate was when combining motor, diplopia, and HRQOL criteria (50%).

Conclusions—Applying motor criteria alone yields highest success rates when evaluating outcomes in adult strabismus surgery, but motor criteria do not fully represent the patient's postoperative status. Combining diplopia criteria with motor criteria provides a more clinically relevant standard for judging the success of adult strabismus surgery. For HRQOL criteria, exceeding 95% limits of agreement, at 6 weeks postoperatively, appears a difficult hurdle to clear for some individual patients, and evaluating change in HRQOL score may be more useful in cohort studies.

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In adults, strabismus surgery is performed primarily to improve ocular alignment and/or to reduce diplopia[1] with the overall aim of improving the patient's health-related quality of life (HRQOL).[2] Other potential benefits of strabismus surgery include improved binocularity,[3-10] expanded binocular visual fields,[5, 10-12] improved head posture[5, 7, 9] and improved social interactions and self-esteem.[1, 2, 5, 13-16] Nevertheless, there are no established standards for evaluating strabismus surgery outcomes and there are few existing data evaluating the performance of different outcome criteria. Motor alignment is the most frequently applied outcome criterion[1] with thresholds such as “less than 10 or 12 prism diopters (pd) of orthotropia” frequently used to define a desirable outcome.[1, 7, 10, 17, 18] One problem with applying purely motor criteria to define strabismus surgery outcomes is that they do not account for symptoms such as diplopia, or consider the impact of treatment on the patient's quality of life. Using motor criteria alone, a patient may be classified a success despite new or persistent diplopia and/or when very dissatisfied with the surgical result. Two additional, relevant criteria for assessment of strabismus surgery outcomes are: 1) postoperative diplopia severity and 2) postoperative HRQOL. Both can be easily assessed during an outpatient examination and both directly address the aims of strabismus surgery in the vast majority of adults. We therefore aimed to compare the performance of motor, diplopia and HRQOL outcome criteria when applied alone or in combination, in adults undergoing strabismus surgery.

Patients and methods

Approval was obtained from the Institutional Review Board, Mayo Clinic, Rochester MN and each patient gave informed consent before participating. All procedures and data collection were conducted in a manner compliant with the Health Insurance Portability and Accountability Act.

Patients

One hundred and seventy-nine adult strabismus patients, undergoing a total of 196 surgeries, were seen in one author's (JMH) clinical practice over 2 years (2009-2010). To be eligible for inclusion in the present study, patients were required to have a 6-week postoperative examination and to have completed Adult Strabismus-20 (AS-20) HRQOL questionnaires at preoperative and 6-week postoperative clinical examinations. We aimed to administer the AS-20 questionnaire pre- and postoperatively to all adult strabismus patients undergoing surgery during the study time period, however over the 2 years 25 (13%) surgical procedures were excluded either because examinations fell outside of our pre-specified 6-week visit window (3 to 21 weeks), or because the AS-20 was inadvertently not completed at pre- or postoperative examinations. The remaining 159 patients (171 surgeries) were included in the study. Median age of included patients was 50 (range 18 to 88) years; 94 (59%) were female and for 150 (94%) race was reported as ‘White.’ Median visual acuity at the time of surgery was 20/20 (range 20/15 to 20/50) in the better eye and 20/25 (range 20/15 to count fingers) in the worst eye. 148 (93%) of 159 included patients had one surgery for analysis, 10 (6%) had two surgeries, and 1 (1%) had three surgeries.

Preoperative assessment was performed a median of 1 day (range 0 to 13 days) before surgery and 6-week postoperative assessment was performed a median of 7 weeks (range 4 to 19 weeks) following surgery. One hundred and seventeen (68%) of 171 surgeries were for strabismus with diplopia (with preoperative evidence of fusion potential), 38 (22%) were for non-diplopic strabismus and 16 (9%) were for strabismus with “atypical” diplopia (i.e. diplopia by history but no evidence of fusion potential, typically childhood strabismus with loss of suppression). For 3 (3%) of 117 surgeries in the diplopia group (with fusion potential), patients had symptoms of visual confusion preoperatively (rather than diplopia) but were grouped with diplopia patients, because surgery aimed to relieve symptoms of

visual confusion. Overall, 79 (46%) of 171 surgeries were for childhood onset / idiopathic strabismus, 50 (29%) neurogenic, 36 (21%) mechanical and 6 (4%) sensory. One hundred and sixteen (68%) of 171 surgeries were uniplanar: 85 (50%) purely horizontal, 27 (16%) purely vertical and 4 (2%) purely torsional. Fifty-five (32%) of 171 surgeries were multiplanar: 29 (17%) horizontal and vertical, 11 (6%) vertical and torsional, 7 (4%) horizontal and torsional and 8 (5%) horizontal, vertical and torsional combined. For 5 (3%) of 171 surgeries, patients were in prism correction at their 6-week postoperative examination. Preoperative AS-20 data have been previously reported on 97 (57%) of 171 surgeries[2, 19-21] and 6-week postoperative AS-20 data have been previously reported on 91 (53%).[2]

Clinical examinations

All patients underwent a full clinical assessment at their preoperative and 6-week postoperative examinations, including measurement of the angle of deviation at distance (3m) and near (1/3m) using simultaneous prism cover test (SPCT) and prism and alternate cover test (PACT). For about half of the surgeries (101 [59%]), diplopia severity was assessed based on the medical history, in which the patient is routinely questioned regarding gaze-specific diplopia frequency. For the remaining 70 (41%) surgeries we utilized a Revised Diplopia Questionnaire, (Smith SJ, Liebermann L, Hatt SR, et al. Quantifying diplopia using a patient-reported outcome questionnaire. Invest Ophthalmol Vis Sci 2011;52:ARVO E-Abstract 6361) recently implemented in our practice. The Revised Diplopia Questionnaire is completed by the patient before their clinical examination and provides a more standardized method of obtaining the patient's self-report of diplopia. Patients are asked to rate the frequency with which, over the past week, they have experienced diplopia straight ahead at distance (primary position) and for reading, as well as in other gaze positions, using a 5-point Likert type scale (Always, Often, Sometimes, Rarely, Never) .

AS-20 questionnaire

The AS-20[2, 20-23] consists of 10 items in a psychosocial subscale and 10 items in a function subscale (full questionnaire with user instructions freely available at: http://public.pedig.jaeb.org/, accessed January 25th, 2012). For each question a 5-point Likert type scale was used for responses: ‘never’ (score 100), ‘rarely’ (score 75), ‘sometimes’ (score 50), ‘often’ (score 25), and ‘always’ (score 0). A psychosocial score (10 items), and function score (10 items) was calculated as a mean of all answered items and ranged from 0 (worst HRQOL) to 100 (best HRQOL). Questions on the psychosocial scale include: “I worry about what people will think about my eyes” and “I am self conscious about my eyes.” Questions on the function scale include: “I cover or close one eye to see things better” and “I avoid reading because of my eyes.” Questionnaires were self-administered and were typically completed before the clinical examination.

Classification of 6-week surgical outcomes

For each criterion, 3 outcome categories were defined a priori: success, partial success or failure (Table 1). For motor criteria, classification as success required less than 10 prism diopters (pd) by SPCT at distance and near, classification as partial success required less than or equal to 15 pd distance and near and classification as failure was made if SPCT was more than 15 pd at distance or near (Table 1). SPCT angle data were used in order to capture purely the tropic element of misalignment which we felt was most likely to reflect the patient's alignment in everyday life. SPCT data also allowed for more direct comparison to previous studies where alignment outcomes are typically reported as within so many prism diopters of orthotropia. PACT data were used to determine surgical dose. For diplopia criteria, a patient was classified as success if diplopia was rated never or only rarely in

primary position distance and for reading, as partial success if diplopia was present never, rarely or sometimes at distance and for reading, and as failure if it was present more than sometimes at distance or for reading (Table 1). The 16 atypical diplopia patients were excluded from any analysis where diplopia criteria were applied, because surgery did not aim to improve symptoms of diplopia, although sometimes this was the fortunate result. For HRQOL criteria, classification as success required pre- to postoperative change in scores exceeding previously published 95% limits of agreement (LOA) on either psychosocial or function scales (psychosocial scale 17.7 points; function scale 19.5 points[21]) (Table 1). For classification as partial success, change in HRQOL scores was required to exceed 50% LOA on either psychosocial or function scales (derived 50% limits of agreement: psychosocial scale 6.1 points, function scale 6.7 points) and for classification as failure, change was less than 50% LOA on both psychosocial and function scales (Table 1).

Analyses

For each included surgical episode (171 surgeries in 159 patients), the performance of motor, diplopia and HRQOL outcome criteria was analyzed by comparing success rates when applying: 1) Motor criteria alone; 2) Diplopia criteria alone; 3) HRQOL criteria alone. Outcome criteria were then combined and success rates determined when applying: 4) Motor plus diplopia criteria; 5) Motor plus HRQOL criteria; 6) Diplopia plus HRQOL criteria; 7) Motor plus diplopia plus HRQOL criteria. For outcomes using combined criteria, success was defined as success on every parameter, partial success was defined as partial success on one parameter and partial success or success on the other(s), and failure was defined as failure on any parameter. In secondary analyses, success rates were evaluated when criteria were applied to sub-groups of patients with diplopic, non-diplopic and atypical diplopic strabismus. All analyses were performed using SAS computer software version 9.2 (Cary, NC).

Results

Applying motor criteria alone, 154 (90%) of 171 surgeries were classified as success, 13 (8%) as partial success and 4 (2%) as failure (Table 2). When applying diplopia criteria alone, 114 (74%) of 155 surgeries were classified as success, 20 (13%) as partial success and 21 (14%) as failure (Table 2). (The 16 atypical diplopia patients were not included in any analyses where diplopia criteria were applied, reducing the denominator from 171 surgeries to 155). When applying HRQOL criteria alone, 102 (60%) were classified as success, 44 (26%) as partial success and 25 (15%) as failure (Table 2). When combining criteria, the highest success rate (104 of 155; 67%) was found for motor and diplopia criteria. The lowest success rate was found when combining all three (motor, diplopia, and HRQOL criteria) (77 of 155; 50%) (Table 2). Adding diplopia criteria to motor criteria resulted in a 23% reduction in success rate (95% CI 14% to 32%), while adding HRQOL criteria to motor plus diplopia criteria resulted in a further 17% reduction (95% CI 7% to 28%).

Diplopic patients

When applying motor criteria alone, 114 (97%) of 117 surgeries for diplopic strabismus were classified as success, 3 (3%) as partial success and 0 (0%) as a failure (Table 3). For diplopia criteria alone, 79 (68%) were classified as success, 18 (15%) as partial success and 20 (17%) as failure (Table 3). For HRQOL criteria alone 77 (66%) were classified as success (68 [58%] success on function scale, 33 [28%] on psychosocial scale, 24 [21%] on both function and psychosocial scales), 24 (21%) as partial success and 16 (14%) as failure (Table 3). When combining criteria, the highest success rate was found for motor and diplopia criteria (79 of 117; 68%) and the lowest success rate (63 of 117; 54%) was found

for diplopia and HRQOL combined and for diplopia, motor, and HRQOL combined (Table 3).

Non-diplopic patients

Applying motor criteria alone, 27 (71%) of 38 surgeries for non-diplopic strabismus were classified as success, 7 (18%) as partial success and 4 (11%) as failure (Table 3). For diplopia criteria alone, 35 (92%) were classified as success, 2 (5%) partial as success and 1 (3%) as failure (Table 3). For HRQOL criteria alone 18 (47%) were classified as success (8 [22%] success on function scale, 14 [38%] on psychosocial scale, 4 [11%] on both function and psychosocial scales), 12 (32%) as partial success and 8 (21%) as failure (Table 3). When combining criteria, the highest success rate was found when combining diplopia and motor (25 of 38; 66%) and the lowest success rate was found when applying motor and HRQOL combined and diplopia, motor and HRQOL combined (14 of 38; 37%) (Table 3).

Atypical diplopia patients

For atypical diplopia surgeries, applying motor criteria alone, 13 (81%) of 16 were classified as success, 3 (19%) as partial success and 0 (0%) as failure (Table 3). As planned, diplopia criteria were not applied when atypical diplopia was present preoperatively. For HRQOL criteria alone, 7 (44%) of 16 were classified as success (2 [13%] success on function scale, 7 [44%] on psychosocial scale, 2 [13%] on both function and psychosocial scales), 8 (50%) as partial success and 1 (6%) as failure (Table 3). When combining motor and HRQOL criteria, 6 (38%) were success, 9 (56%) partial success, and 1 (6%) failure (Table 3).

Discussion

Applying motor outcome criteria alone yielded the highest postoperative success rate in our diverse population of adults undergoing strabismus surgery. Adding diplopia criteria to motor criteria resulted in slightly lower success rates, but combining motor and diplopia criteria provides a more clinically relevant assessment of overall outcome. When HRQOL criteria were applied, the success rate was lower, suggesting our HRQOL criteria presented a more difficult threshold for some patients to exceed.

In previously published large case series' of strabismus surgery in adults where motor criteria were applied to assess outcomes, Keech et al[24] reported a motor success rate of 69% in 125 adults with exodeviations and 77% in 61 patients with esodeviations. In the study by Keech et al[24], motor success was defined as <10 pd horizontal and 5 pd vertical tropia for non-fusing patients. Hertle[25] reported an 85% success rate in 255 adults, using < 12 pd horizontal and 5 pd vertical tropia to define motor success, and Beauchamp et al[17] reported a 72% success rate in 216 adults using ≤ 8 pd horizontal and 2 pd vertical tropia to define motor success. In a more recent study, Zhang et al[26] applied a threshold of ≤10 pd horizontal and ≤2 pd vertical to define success (presumed to be tropia measurements) in 491 adults, and reported success rates of 61% and 75% in adjustable and non-adjustable groups respectively. When we applied motor criteria of < 10 pd in both the vertical and horizontal meridian to define success, we found an overall motor success rate of 90% in our cohort of 171 surgeries, which compares favorably with the motor success rates of these previous studies. Our high motor success rate may be because we used <10 pd to define success in both horizontal and vertical meridians whereas the other studies used a threshold of 2 to 5 pd for successful vertical alignment. Nevertheless, if we applied a more stringent threshold of ≤2 pd for successful vertical alignment, our overall motor success rate would be only slightly reduced, from 90% to 86%.

Regarding reasonable magnitudes of residual deviations, a previous study by Larson et al[27] simulated various degrees of ocular misalignment in photographs and found that the threshold for reliable detection of horizontal misalignment (esotropia and exotropia) was the same as the threshold for detection of hypertropic misalignment (12.5 pd). For hypotropic misalignment the threshold was larger (20 pd). These data would support our approach of using the same motor threshold (<10 pd), for both vertical and horizontal meridians. Nevertheless, small variations in definitions of motor success do not impact our primary aim of comparing motor, diplopia and HRQOL outcome measures.

Diplopia criteria are less frequently and less uniformly reported than motor criteria in studies of adult strabismus surgery outcomes. Previously reported methods of assessing diplopia vary considerably from those used in this present study, making it difficult to compare outcomes. Hertle[25] defined “sensory success” as restoration of a field of single binocular vision ≥ 20 degrees, or regaining central or peripheral fusion with orthotropia in primary position and at near. In a study of adults with Graves' ophthalmopathy, Nassar et al[28] defined a good outcome as a field of single binocular vision > 50% and heterophoria in the primary position. Other authors such as Beauchamp et al report diplopia outcomes in terms of resolution or lack thereof. We applied diplopia criteria based on patient-reported diplopia frequency in primary position and in reading gaze, to try and capture diplopia as experienced by the patient in everyday life. Using this approach, we found a success rate of 68% in diplopia patients. In a previous study we found that a diplopia questionnaire (similar to the one used in this present study) more closely represented the patient's overall experience than diplopia assessment using the Goldmann perimeter.[29] We therefore propose standardized, patient-reported quantification of diplopia severity, using a tool such as the Revised Diplopia Questionnaire, (Smith SJ, Liebermann L, Hatt SR, et al. Quantifying diplopia using a patient-reported outcome questionnaire. Invest Ophthalmol Vis Sci 2011;52:ARVO E-Abstract 6361) as more likely to capture the patient's everyday experience of diplopia than clinic-based testing. The diplopia questionnaire method also has the advantage of being easily implemented in any clinical practice.

As might be predicted, the performance of diplopia outcome criteria differed depending on the type of strabismus. Applying diplopia criteria uniformly, across all patients, may seem inappropriate because, in patients who are non-diplopic preoperatively, for example, “success” simply reflects the continued absence of diplopia. Nevertheless, we felt that it was important to apply diplopia criteria in this group in order to identify those patients who unfortunately develop diplopia postoperatively. Such patients may be inappropriately classified as success if diplopia criteria were not applied. In contrast, it would not be appropriate to apply diplopia criteria if improvement or continued absence of diplopia was not an expected surgical outcome, as in patients with loss of suppression and “atypical” diplopia. Of interest 6 (38%) of the 16 atypical diplopia patients in this study, had complete resolution of their diplopia postoperatively, but this is considered a “bonus” in this less common type of diplopia.

When combining outcome criteria, we found that overall success rates differed, ranging from 50% to 67%. The highest success rates for combined criteria were found when combining motor and diplopia, and the lowest when combining motor, diplopia and HRQOL. The study by Beauchamp et al[17] also examined the effect of combining different outcome criteria, but unlike the findings of our present study, found the lowest success rate (9%) when combining motor alignment and diplopia criteria. Nevertheless, the Beauchamp study[17] used “no reported diplopia” to define diplopia success and this standard may be difficult to achieve, especially in patients with preoperative diplopia and incomitant strabismus, as residual diplopia often persists in peripheral gaze positions. Based on the findings of this present study, combining motor criteria with assessment of diplopia

frequency in primary position and for reading, appears to provide a more clinically relevant and representative measure of success than using motor criteria alone. Using combined motor and diplopia criteria is appealing when one considers a hypothetical patient with, for example, 6 pd of vertical deviation. Without diplopia, 6 pd of vertical deviation should almost always be considered a success, but with diplopia, should be considered a failure. These examples provide further rationale for using <10 pd for motor success, whether horizontal or vertical, when the intent is to combine with diplopia criteria.

There are few previous data analyzing adult strabismus surgery outcomes based on HRQOL criteria alone. In the present study we found that success rates were lower when applying HRQOL criteria alone (60%) than when applying motor criteria alone (90%) or diplopia criteria alone (74%). There are a number of reasons why a patient might not have improvement of HRQOL scores despite improved alignment and improved diplopia. Residual discomfort or redness at the 6-week visit may limit the patient's perception of improvement. We recently reported that a greater proportion of successfully aligned patients exceeded 95% LOAs 1 year following surgery than at 6 weeks.[23] Alternatively, some patients may have been unable to exceed the 95% LOAs due to high HRQOL scores preoperatively (ceiling effect). When we examined our data for possible ceiling effects, we found that 8% were unable to exceed the 95% LOAs on both function and psychosocial scales due to high preoperative scores and therefore could not meet our definition of HRQOL success. In this small proportion of patients the current AS-20 scoring method fails to identify preoperative concerns and therefore success cannot be reasonably defined using HRQOL for these patients.

Previous studies have shown that personality can influence HRQOL[30-32] with lower HRQOL in e.g. Type D personality[30] and neuroticism.[31] Persons with Type D personality have social inhibition and a general disposition to experience negative mood states including anger, fearfulness and depression.[33] It would be of interest to study personality in adults with strabismus and correlate to HRQOL to better understand how personality may affect the patient's rating of outcome. Also, it appears that using 95% LOAs to assess change in HRQOL scores presents a difficult threshold for some patients to exceed, possibly due to individual patient variability. Evaluating change in HRQOL scores at a cohort level may prove more useful. It was interesting to note that, in this present study, success rates were not vastly different when applying HRQOL criteria in isolation (60%) and when applying in combination with motor criteria (56%) or in combination with diplopia criteria (52%). Nevertheless, when using HRQOL criteria to evaluate treatment outcomes, it seems most reasonable to combine with objective measures such as motor and / or diplopia criteria.

There are some limitations to this study. The Revised Diplopia Questionnaire was developed later in the study time period and therefore could not be utilized on every patient. Nevertheless, history-taking was essentially standardized and included very similar questions to those used in the Revised Diplopia Questionnaire. Also, we used the same prism diopter value for both horizontal and vertical motor alignment success, whereas some previous studies use a lower threshold for vertical alignment. Nevertheless, even if a threshold of ≤ 2PD was applied in our dataset, the motor success rate reduced by only 4% (from 90% to 86%). A small number of surgeries (N=25) performed during the study time period were not eligible to be included in this study either because patients did not attend for an examination in our 6-week time frame, or because the AS-20 questionnaire was inadvertently not completed pre- or postoperatively, but there is no reason to believe that the relative performance of outcome measures in these patients would be any different from the included cohort. Finally, we designed outcome criteria that functioned appropriately across a wide range of adult strabismus types, but there are rare exceptions when the criteria do not perform optimally. For example, non-diplopic or atypical diplopia patients with eyestrain

that does not improve postoperatively may still be classified a success based on motor and diplopia criteria. Also, patients with non-diplopic intermittent exotropia may still have moderate latent strabismus postoperatively yet be labeled a success. To completely categorize such rare eventualities, a more complex, condition-specific classification system would need to be employed.

Applying motor criteria alone yields high success rates when assessing outcomes in adult strabismus surgery, but incorporating diplopia criteria is important for providing a more clinically relevant and representative summary of surgical outcome. Combining motor and diplopia criteria using a simple, patient administered method of diplopia assessment, provides an accessible means of judging the success of adult strabismus surgery. For HRQOL criteria, exceeding 95% limits of agreement, at 6 weeks postoperatively, appears a difficult hurdle to clear for some individual patients, and evaluating change in HRQOL score may be more useful in cohort studies.

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Table 1

Criteria used to classify postoperative outcomes 6-weeks following strabismus surgery.

	Success (All criteria must be met)	Partial success (All criteria must be met)	Failure (If any one criterion met)
Motor criteria			
Angle of deviation by SPCT* distance	< 10 prism diopters	≤ 15 prism diopters	> 15 prism diopters
Angle of deviation by SPCT near	< 10 prism diopters	≤ 15 prism diopters	> 15 prism diopters
Diplopia criteria			
Diplopia / visual confusion primary position distance	None or “rare”	None, “rare” or “sometimes”	“Always” or “often”
Diplopia / visual confusion reading	None or “rare”	None, “rare” or “sometimes”	“Always” or “often”
Prism	Not allowed	Allowed	Not applicable
Bangerter foil / occlusion	Not allowed	Not allowed	Allowed
Health-related quality of life criteria			
Psychosocial and function AS-20** scales	Exceeds 95% LOA † on either psychosocial or function scale	Exceeds 50% LOA on either psychosocial or function scale	Does not exceed 50% LOA on both psychosocial and function scales

*SPCT = Simultaneous Prism and Cover Test

**AS-20 = Adult Strabismus-20 health-related quality of life questionnaire

†LOA = Limits of agreement.

95% limits of agreement are: 17.7 points for the psychosocial scale and 19.5 points for the function scale.

50% limits of agreement are: 6.1 points for the psychosocial scale and 6.7 points for the function scale.

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Table 2

Performance of motor, diplopia and health-related quality of life (HRQOL) criteria when assessing 6-week postoperative outcomes in 171 strabismus surgeries (159 adult strabismus patients).

Outcome criteria	Number of surgeries	Success	Partial success	Failure
Motor criteria alone	171	154 (90%)	13 (8%)	4 (2%)
Diplopia criteria alone	155*	114 (74%)	20 (13%)	21 (14%)
HRQOL criteria alone	171	102 (60%)	44 (26%)	25 (15%)
Motor + diplopia criteria	155*	104 (67%)	26 (17%)	25 (16%)
Motor + HRQOL criteria	171	96 (56%)	48 (28%)	27 (16%)
Diplopia + HRQOL criteria	155*	81 (52%)	38 (25%)	36 (23%)
Motor + diplopia + HRQOL criteria	155*	77 (50%)	40 (26%)	38 (25%)

Success, partial success and failure were determined according to pre-specified criteria (see Table 1). Success rates are shown across all patients, regardless of preoperative diplopia status.

*Diplopia criteria were not applied when atypical diplopia was present preoperatively (N=16 surgeries).

Table 3

Performance of motor, diplopia and health-related quality of life (HRQOL) criteria when assessing 6-week postoperative outcomes, in 171 strabismus surgeries (159 adult strabismus patients), showing patients grouped according to preoperative diplopia status.

	Success	Partial success	Failure
Surgeries in diplopic patients (n=117)			
Motor criteria	114 (97%)	3 (3%)	0 (0%)
Diplopia criteria alone	79 (68%)	18 (15%)	20 (17%)
HRQOL criteria alone	77 (66%)	24 (21%)	16 (14%)
Motor + diplopia criteria	79 (68%)	18 (15%)	20 (17%)
Motor + HRQOL criteria	76 (65%)	25 (21%)	16 (14%)
Diplopia + HRQOL criteria	63 (54%)	26 (22%)	28 (24%)
Motor + diplopia + HRQOL criteria	63 (54%)	26 (22%)	28 (24%)
Surgeries in non-diplopic patients (n=38)			
Motor criteria	27 (71%)	7 (18%)	4 (11%)
Diplopia criteria alone	35 (92%)	2 (5%)	1 (3%)
HRQOL criteria alone	18 (47%)	12 (32%)	8 (21%)
Motor + diplopia criteria	25 (66%)	8 (21%)	5 (13%)
Motor + HRQOL criteria	14 (37%)	14 (37%)	10 (26%)
Diplopia + HRQOL criteria	18 (47%)	12 (32%)	8 (21%)
Motor + diplopia + HRQOL criteria	14 (37%)	14 (37%)	10 (26%)
Surgeries in atypical diplopia patients (n=16)			
Motor criteria	13 (81%)	3 (19%)	0 (0%)
HRQOL criteria alone	7 (44%)	8 (50%)	1 (6%)
Motor + HRQOL criteria	6 (38%)	9 (56%)	1 (6%)