

Reoperation following strabismus surgery among Medicare beneficiaries: Associations with geographic region, academic affiliation, surgeon volume, and adjustable suture technique

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Purpose: The objective of this study was to determine the associations of strabismus surgery reoperation rates in a large national database of provider payments with geographic region, practice type and volume, and the availability of adjustable suture technique. **Methods:** Fee-for-service payments to providers for medicare beneficiaries having strabismus surgery between 2012 and 2015 were retrospectively analyzed to identify reoperations in the same calendar year. The adjustable-suture technique was considered to be available to the patient if the patient's surgeon billed for adjustable sutures. Predictors of reoperation in the same calendar year were determined by multivariable logistic regression. **Results:** Availability of the adjustable suture technique was not associated with reoperation rate in multivariable analysis among 5971 patients having horizontal muscle surgery (odds ratio, [OR] 0.86, $P = 0.29$), 2840 patients having vertical muscle surgery (OR 0.98, $P = 0.93$), or 1199 patients having surgery with scarring or restriction (OR 0.86, $P = 0.61$). For horizontal surgery, the reoperation rate was higher in academic practices (OR 1.67), as compared with community practices, and in the South (OR 2.85) and West (OR 1.92, all $P < 0.001$). The reoperation rate was unchanged with surgeons in the lowest-quartile of surgical volume. Among surgeons paid for horizontal surgery, 45% of surgeons in the Northeast, the West, or Florida coded for adjustable sutures, compared with 8% of surgeons elsewhere ($P < 0.001$). **Conclusion:** The availability of the adjustable-suture technique was not associated with reoperation rate after strabismus surgery in this large national database. Having surgery by a lower-volume surgeon was not associated with a higher reoperation rate. The reoperation rate was higher when surgery was conducted in an academic practice, or in certain regions of the country. Adjustable sutures are largely a bicoastal practice.

Key words: Adjustable sutures, strabismus, surgery

Strabismus surgery outcome might be influenced by aspects of the surgical practice, including geographic region, university affiliation, surgeon volume, as well as familiarity of the surgeon with adjustable sutures.

Adjustable sutures can be used to permit refinement of ocular alignment in the immediate postoperative period.^[1-4] Two small randomized controlled trials of adjustable versus conventional suture strabismus surgery have been performed.^[5,6] The first trial, in 45 patients, favored adjustable sutures.^[5] A second trial with 30 patients in each group found no significant difference in motor outcome at 6 months between the two groups.^[6]

Retrospective case series typically suggest better outcomes with adjustable sutures.^[7] Some single-center case series have no control group.^[1,8] The small number of surgeons in both case series and randomized trials leaves uncertainty about generalizability.^[1,8-10]

An analysis of private insurance payments for strabismus surgery demonstrated a lower reoperation rate with adjustable sutures for horizontal muscle surgery, but not for vertical

muscle surgery.^[3] A similar analysis conducted in children demonstrated higher reoperation rates with adjustable sutures.^[4]

Additional practice variables might influence strabismus surgery outcomes. For many types of surgery,^[11,12] including cataract,^[13] higher-volume surgeons are found to have better outcomes. At an academic center, strabismus surgery performed with a more junior surgical assistant or with additional surgical trainees has been associated with a longer operative time.^[14] Geographic variation in use of strabismus surgery and other medical services has been demonstrated.^[15-17]

To evaluate the association of practice volume, academic affiliation, geographic region, and suture technique with strabismus surgery outcome, we evaluated reoperations for

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Cite this article as: Christensen MR, Pierson K, Leffler CT. Reoperation following strabismus surgery among Medicare beneficiaries: Associations with geographic region, academic affiliation, surgeon volume, and adjustable suture technique. *Indian J Ophthalmol* 2018;66:1149-53.

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Manuscript received: 04.01.18; **Revision accepted:** 03.04.18

Access this article online

Website:

www.ijo.in

DOI:

10.4103/ijo.IJO_18_18

Quick Response Code:



strabismus surgery in the database of Medicare payments to providers for 2012 through 2015.^[18]

Methods

This study was approved by the hospital Office of Research Subjects Protection. We downloaded the national database of Medicare payments for 2012 through 2015.^[18] This database is not a random sample. Rather, the database includes payment data for every practitioner in the country who received Medicare fee-for-service payments. In the United States, Medicare is a single-payer, national health insurance program administered by the federal government serving patients over age 65 and younger patients with disabilities. Each current procedural terminology (CPT) code had to be paid to the provider for at least 11 beneficiaries in 1 year for that particular CPT to be listed under that provider for the year.

We evaluated rates of reimbursed reoperations in patients having one horizontal muscle strabismus surgery (CPT 67311), one vertical muscle surgery (CPT 67314), adjustable suture placement (CPT 67335), and surgery with scarring of extraocular muscles (e.g., prior ocular injury, strabismus, or retinal detachment surgery) or restrictive myopathy (e.g., dysthyroid ophthalmopathy; CPT 67332). These CPT codes were selected because they are the most commonly coded strabismus procedures. Other strabismus surgery codes were not used frequently enough to draw meaningful conclusions. The reoperation rate was determined from the numbers of beneficiaries and beneficiary service days. For instance, if a given provider treated 13 beneficiaries with a particular CPT code in a given year, but there were 14 beneficiary service days for this code, then 1 of the 13 beneficiaries had a reoperation. The unit of analysis was the patient (beneficiary). If the surgeon received any payments for CPT 67335, then patients operated by that provider were counted in the group for whom the adjustable-suture technique was available. Otherwise, the patients were counted in the group for whom the adjustable-suture technique was not available.

We compared the likelihood of reoperation in patients having strabismus surgery when the adjustable technique was available with patients having surgery when the adjustable technique was not available. We also evaluated associations of reoperation rate with academic or community-based practice, and surgery in a practice with the lowest or highest surgical volume by quartile. Reoperation rate was evaluated in major geographic regions – Northeast (CT, ME, MA, NH, RI, VT, NJ, NY, PA), Midwest (IN, IL, MI, OH, WI, IA, KA, MN, MO, NE,

ND, SD), South (DE, MD, DC, FL, GA, NC, SC, VA, WV, AL, KY, MS, TN, AR, LA, OK, TX), and West (AZ, CO, ID, NM, MT, UT, NV, WY, AK, CA, HI, OR, WA).^[19] We excluded data from retinal oncologists, who might have been coding for muscle surgeries when detaching muscles to place radiotherapy plaques. Proportions were compared by Fisher's exact test. Availability of the adjustable suture technique and variables significant in univariate analysis were evaluated by multivariable logistic regression in XLSTAT version 2017.6 (Addinsoft, New York, NY, USA).

Results

Horizontal muscle surgery

Reoperations in the same calendar year took place in 405 of 5971 patients (6.8%) having one-horizontal muscle surgery (CPT 67311). In univariate analysis, reoperations were less common when the adjustable suture was available (5.5%) than when this technique was not available (7.3%, $P = 0.01$). However, in a multivariable analysis which controlled for practice type, region, and volume, availability of the adjustable suture technique was no longer a significant predictor of reoperations (odds ratio [OR] 0.86, 95% confidence interval [CI] 0.66–1.13, $P = 0.29$, Table 1).

Patients had a higher reoperation rate in academic practices (8.1%) than in community practices [6.3%, multivariable $P < 0.001$, Table 1]. The reoperation rate was higher for patients in the South (9.1%), or in the West (5.8%) than elsewhere (3.8%, both $P < 0.001$). Before controlling for other factors, patients appeared to have a higher reoperation rate in either the lowest or highest volume practices, with a reoperation rate of 9.5% in the lowest volume quartile (≤ 38 patients in 4 years), 4.7% in intermediate volume practices, and 8.3% for highest volume quartile practices (≥ 94 patients in 4 years). However, after controlling for practice suture method, academic affiliation, and region, the lowest volume quartile was not associated with reoperations ($P = 0.83$), and the association with reoperations of the highest volume quartile just missed conventional statistical significance [OR 1.27, 95% CI 1.00–1.63, $P = 0.054$, Table 1]. The reoperation rate for each year from 2012 to 2015 was essentially stable: 6.4%, 7.1%, 7.8%, and 6.0% ($P = 0.84$ for later vs. earlier years).

Vertical muscle surgery

Reoperations in the same calendar year took place in 197 of 2840 patients (6.9%) having one-vertical muscle surgery (CPT 67314). In univariate analysis, the reoperation rate was

Table 1: Reoperation after horizontal muscle surgery (current procedural terminology 67311)

Practice characteristic	Reoperations with factor			Multivariable model	
	Present, <i>n</i> (%)	Absent (%)	<i>P</i>	OR (95% CI)	<i>P</i>
Adjustable suture	100/1804 (5.5)	7.3	0.01	0.86 (0.66-1.13)	0.29
Academic	123/1525 (8.1)	6.3	0.03	1.67 (1.32-2.10)	<0.001
South	264/2904 (9.1)	4.6	<0.001	2.85 (2.15-3.77)	<0.001
West	70/1203 (5.8)	7.0	0.14	1.92 (1.34-2.75)	<0.001
Low volume*	140/1479 (9.5)	5.9	<0.001	1.03 (0.79-1.33)	0.83
High volume*	121/1449 (8.3)	6.2	0.008	1.27 (1.00-1.63)	0.054
All practices	405/5971 (6.8)	-	-	-	-

*Low volume quartile was ≤ 38 patients over 4 years. High volume quartile was ≥ 94 patients over 4 years. CI: Confidence interval, OR: Odds ratio

less common when the adjustable suture was available (5.8%) than when this technique was not available (7.6%), though not significantly so [$P = 0.08$, Table 2]. In a multivariable analysis which controlled for practice type and region, availability of the adjustable suture technique was not associated with reoperations [OR 0.98, 95% CI 0.67–1.45, $P = 0.93$, Table 2].

Academic practices had a higher reoperation rate (8.3%) than community practices [6.2%, multivariable $P = 0.004$, Table 2]. The reoperation rate was higher for patients in the South (9.1%), than elsewhere (5.1%, $P = 0.006$).

The reoperation rate was 9.5% for practices in the highest volume quartile (≥ 81 patients in 4 years), and 6.0% for other practices ($P = 0.001$). After controlling for practice type, and region, the association of reoperations with high surgical volume was no longer significant [OR 1.14, $P = 0.52$, Table 2]. The reoperation rate for each year from 2012 to 2015 was essentially stable: 7.0%, 6.5%, 7.0%, and 7.1% ($P = 0.77$ for later vs. earlier years).

Surgery with restriction or scarring

Reoperations in the same calendar year took place in 102 of 1199 patients (8.5%) having strabismus surgery involving restriction or scarring [CPT 67332, Table 3]. In univariate analysis, reoperations tended to be less common when the adjustable suture was available (7.1%) than when this technique was not available (9.6%, $P = 0.12$). However, in a multivariable analysis, availability of the adjustable suture technique was not a significant predictor of reoperations [OR 0.83, 95% CI 0.50–1.37, $P = 0.47$, Table 3].

There was a similar reoperation rate in academic (9.2%) and community practices [7.8%, multivariable OR 1.17, $P = 0.47$, Table 3]. The reoperation rate was 10.2% in the

South ($P = 0.08$), 12.0% in the West ($P = 0.01$), and 5.3% elsewhere [Table 3]. The reoperation rate was 7.9% in the lowest volume quartile (≤ 24 patients in 4 years), 7.7% in intermediate volume practices, and 10.4% for highest volume quartile practices [≥ 76 patients in 4 years, all $P \geq 0.16$, Table 3]. The reoperation rate for each year from 2012 to 2015 was essentially stable: 8.1%, 8.0%, 8.1%, and 9.9% ($P = 0.53$ for later vs. earlier years).

Adjustable suture surgery

Reoperations in the same calendar year took place in 126 of 2473 patients (5.1%) having adjustable suture strabismus surgery (CPT 67335). There was a similar reoperation rate in academic (5.8%) and community practices [4.5%, multivariable OR 1.06, $P = 0.78$, Table 4]. The reoperation rate was 4.1% in the lowest volume quartile practices (≤ 38 patients in 4 years), 4.3% in intermediate volume quartiles, and 7.7% for practices in the highest volume quartile (≥ 97 patients in 4 years, $P = 0.003$).

The reoperation rate for each year from 2012 to 2015 was: 4.6%, 3.8%, 5.6%, and 6.5%. The increase in years 2014–2015 was of marginal statistical significance ($P = 0.04$ for later vs. earlier years).

Surgeons using adjustable sutures were clustered along the coasts. For the Northeast, the West, plus Florida 30 of 67 horizontal muscle surgeons coded for adjustable sutures (45%). For the Midwest and the South (excluding Florida), only 6 of 76 horizontal muscle surgeons coded for adjustable sutures (8%, $P < 0.001$).

Discussion

This study evaluated reoperation rate after strabismus surgery in a large national database. Reoperations were used

Table 2: Reoperation after vertical muscle surgery (current procedural terminology 67314)

Practice characteristic	Reoperations with factor			Multivariable model	
	Present, n (%)	Absent (%)	P	OR (95% CI)	P
Adjustable suture	62/1065 (5.8)	7.6	0.08	0.98 (0.67-1.45)	0.93
Academic	85/1027 (8.3)	6.2	0.04	1.56 (1.15-2.11)	0.004
South	117/1280 (9.1)	5.1	<0.001	1.76 (1.18-2.62)	0.006
Low volume*	42/738 (6.0)	7.4	0.13	-	-
High volume*	72/756 (9.5)	6.0	0.001	1.14 (0.76-1.72)	0.52
All practices	197/2840 (6.9)	-	-	-	-

*Low volume quartile was ≤ 27 patients over 4 years. High volume quartile was ≥ 81 patients over 4 years. CI: Confidence interval, OR: Odds ratio

Table 3: Reoperation after surgery involving restriction or scarring (current procedural terminology 67332)

Practice characteristic	Reoperations with factor			Multivariable model	
	Present, n (%)	Absent (%)	P	OR (95% CI)	P
Adjustable suture	37/524 (7.1)	9.6	0.12	0.83 (0.50-1.37)	0.47
Academic	53/574 (9.2)	7.8	0.41	1.17 (0.77-1.78)	0.47
South	54/530 (10.2)	7.2	0.08	1.83 (1.07-3.14)	0.03
West	22/183 (12.0)	7.9	0.08	2.41 (1.32-4.39)	0.004
Low volume*	25/318 (7.9)	8.7	0.73	-	-
High volume*	34/325 (10.4)	7.8	0.16	-	-
All practices	102/1199 (8.5)	-	-	-	-

*Lowest volume quartile was ≤ 24 patients over 4 years. Highest volume quartile was ≥ 76 patients over 4 years. CI: Confidence interval, OR: Odds ratio

Table 4: Reoperations following adjustable suture strabismus surgery (current procedural terminology 67335)

Practice characteristic	Reoperations with factor			Multivariable model	
	Present, n (%)	Absent (%)	P	OR (95% CI)	P
Academic	64/1101 (5.8)	4.5	0.17	1.06 (0.72-1.56)	0.78
Low volume*	23/567 (4.1)	5.4	0.23	-	-
High volume*	47/611 (7.7)	4.2	0.001	1.84 (1.23-2.76)	0.003
All practices	126/2473 (5.1)	-	-	-	-

*Lowest volume quartile was ≤ 38 patients over 4 years. Highest volume quartile was ≥ 97 patients over 4 years. CI: Confidence interval, OR: Odds ratio

as an outcome measure, as recommended^[20] and performed previously.^[2-4] Planned reoperation is an indication that the goals of surgery have not been achieved.^[21]

The reoperation rate was higher when surgery was conducted in an academic practice, and in the South or West. Availability of the adjustable-suture technique was not associated with the reoperation rate after controlling for other factors. Surgery by a lower-volume surgeon was not associated with a higher reoperation rate.

We assumed that lower volume surgeons might have worse outcomes, as noted with other types of surgery.^[11-13] However, reoperation rate was not significantly higher with strabismus surgery performed by a surgeon in the lowest volume quartile, after controlling for other practice factors. In fact, procedures by surgeons in the highest volume quartile actually tended to have a higher reoperation rate for some procedure codes, though the association was only of borderline statistical significance for horizontal muscle surgery. Perhaps, more aggressive surgeons with a low threshold for both initial and subsequent operations tend to have higher volumes. The study does not address reoperation rates in the lowest-volume settings (surgeons who were not paid for 11 surgeries in a single year).

The higher reoperation rate in an academic setting (OR 1.67), as opposed to community practice might have various causes. Universities might have more complex patients. The decrease in the strength of the association with an analysis of the subset of patients with scarring or restriction (OR 1.17) supports this notion (because all practices are compared on a subset of equally difficult patients). Other possible factors explaining a higher reoperation rate at universities might include the presence of trainees, variation associated with innovation, or a lower threshold for reoperation. This study design only counted reoperations by the same provider. A tendency for community practices to send their reoperations to universities, but for universities to hold on to their complex patients, might produce a spurious association.

Among children in the United Kingdom, wide geographic variation in the incidence of strabismus surgery has been observed.^[15] Use of Medicare services demonstrates substantial geographic variation.^[16] A previous review of Medicare claims found that strabismus was diagnosed less often in the South and that strabismus surgery was performed more often in the West.^[17] Our study observed that strabismus surgery reoperation rates were higher in the South and the West. Factors in either patient demographics or medical culture which account for this variation deserve further investigation.

For most procedure codes, the reoperation rate fluctuated to a small degree from year to year, without showing noticeable

trends. In fact, the reoperation rate with adjustable sutures increased slightly in the latter half of the series. If strabismus surgeons are getting better at avoiding reoperations, the change must be occurring on a time scale larger than 4 years.

In the modern era, adjustable suture strabismus surgery was introduced by Jampolsky in San Francisco in the 1970s.^[22] Forty years later, the technique is still a bicoastal practice.

The analysis of adjustable suture availability was similar to other studies examining the association of resource availability on patient outcomes, as discussed previously.^[2] An example of such a study would include an analysis of the association of the availability of fluoridated water with the incidence of dental caries.^[23] Such studies can be conducted without knowing which members of the community drink the fluoridated tap water, and which drink bottled water. In short, if adjustable sutures improve strabismus surgery outcomes, then patients who have surgery in a setting in which the technique is available should tend to have better outcomes than patients operated without access to this technique.

We previously noted an apparently lower reoperation rate with adjustable sutures in some instances.^[2-4] However, unlike previous studies,^[2-4] the present study controlled for geographic region and academic affiliation. The 2012 Medicare data did demonstrate a lower reoperation rate when the adjustable suture technique was available.^[2] The absence of association in the 4-year analysis is due in part to the higher reoperation rate seen with adjustable sutures in subsequent years.

Similarly, we previously demonstrated in a private insurance database that when adjustable sutures were used, reoperation rates were significantly lower for horizontal muscle surgery (OR 0.69) but not for vertical muscle surgery.^[3] The present analysis examined the availability of the adjustable suture technique to the patient, regardless of whether the surgeon elected to use the technique for that patient.

Over 80% of Medicare beneficiaries qualify on the basis of age 65 or over. The remainder qualifies on the basis of disability. The study results may not apply to a different population.

The study was based on payments to providers for reoperations. Provider coding might be inaccurate or incomplete.^[24] Reoperations for which payment was denied were not reflected. Some unsatisfied patients might forgo reoperation, or obtain reoperation in a subsequent year or with a different provider.

Conclusion

The availability of the adjustable-suture technique was not associated with reoperation rate after strabismus surgery in

this large national database. Having surgery by a lower-volume surgeon was not associated with a higher reoperation rate. The reoperation rate was higher when surgery was conducted in an academic practice. In the United States, strabismus surgery reoperation rate is higher in the South and West, and the adjustable suture technique is more common along the coasts.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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