The Epidemiology of Reoperation After Flexor Pulley Reconstruction

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Purpose We used a statewide database to determine the incidence of pulley reconstruction and to evaluate the influence of demographics on reoperation. We hypothesized that age, insurance status, and concomitant nerve or tendon procedure would influence the likelihood of reoperation.

Methods We used the Statewide Planning and Research Cooperative System ambulatory surgery database from New York, which represents all outpatient surgery in the state. Patients who had flexor pulley reconstruction from 1998 to 2009 were identified using Current Procedural Terminology 4 codes. Subsequent surgery records for these patients were identified through 2010, allowing at least 1 year follow-up. Concomitant nerve procedure and flexor tendon repair/reconstruction were identified. The type and timing of subsequent procedures, including tenolysis and repeat pulley reconstruction, were recorded. Univariate statistics were calculated to compare age, sex, and payer type between patients with and without reoperation. A multivariable, logistic regression model was used to evaluate the association of the demographics with the chances of having reoperation.

Results There were 623 patients who had flexor pulley reconstruction from 1998 to 2009. The incidence of pulley reconstruction was 0.27 per 100,000 persons, with an annual frequency of 52 procedures. There were 39 (6%) reoperations. There was no difference in age, concomitant nerve or tendon repair, or workers' compensation between patients with and without reoperation. Regression modeling showed a higher likelihood among men of having reoperation.

Conclusions Flexor pulley reconstructions are rare. One-quarter of surgeons performed only one flexor pulley reconstruction over a 12-year period. The 6% reoperation rate is similar to our previous findings for flexor tendon repair using similar methodology. Our report provides information that may be useful in counseling patients. *(J Hand Surg 2013;38A:1705–1711.* *Copyright © 2013 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Prognostic II.

Key words flexor pulley, outcomes, epidemiology, socioeconomic

PREVIOUS INVESTIGATIONS HAVE suggested that flexor pulley reconstructions are uncommon,[1] and when compared to the wealth of clinical reports on flexor tendon repair, there are relatively few reports on series of patients having flexor pulley reconstruction. Detailed clinical outcomes are limited to case reports[2–4] and single-center clinical series,[1,5–9] the largest of which consisted of 23 patients.[8] The relative

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paucity of epidemiologic and clinical literature makes it difficult both to guide best management of these injuries and to counsel patients about risks following surgery.

Although the anatomy, biomechanics, and surgical technique of flexor pulley reconstruction have been extensively reviewed,[10–14] the incidence and risk profile of having surgery remain incompletely explored. We used a statewide administrative database to determine the incidence of flexor pulley reconstruction and to evaluate the influence of demographic characteristics on the frequency of secondary surgery. We hypothesized that age, payer status, and whether a concomitant procedure (digital nerve repair or flexor tendon repair/reconstruction) was performed would influence the likelihood of reoperation after flexor pulley reconstruction.

METHODS

We used the Statewide Planning and Research Cooperative System ambulatory surgery database from New York, which represents all outpatient surgery in the state. Unique patient identifiers have been available since 1997, allowing a patient to be followed over time after being treated in New York, provided that subsequent care occurred in New York. The database has been used for previous research on the frequency and complications of flexor tendon repairs[15] and other orthopedic surgeries.[16–18] The time period for inclusion in the current study was 1998 to 2009. Subsequent surgery records for these patients were identified through the end of 2010, allowing a minimum of 1 year follow-up for all patients. No additional data for later years were available. Patients who had flexor pulley reconstruction were identified using Current Procedural Terminology 4 (CPT4) codes 26500, 26502, and 26504. Patients who had previously had tenolysis or had concomitant tenolysis were excluded to minimize the chances of including patients who had prior flexor pulley reconstruction. Concomitant nerve procedures (CPT4 codes 64831, 64832, 64834, 64837, and 64872) and flexor tendon repair or reconstruction (CPT4 codes 26350, 26356, 26370, 26352, 26357, 26358, and 26372) during the flexor pulley reconstruction were noted. The type and timing of any procedures that occurred after the index procedure within the state of New York were recorded, specifically tenolysis (CPT4 codes 26440 and 26442), irrigation and debridement (CPT4 code 10180), and repeat flexor pulley reconstruction.

The current project was verified as exempt from further review by our institution under the categories of the data being publically available and not identifiably linked to individual patients.

Demographic information was recorded for each patient, including age, sex, and payer status. Incidence per 100,000 persons was calculated using United States census data for New York.[19] The number of cases performed per surgeon during the study period was calculated. Reoperation rate was compared among surgeons with 1, 2 to 4, and 5 or more flexor pulley reconstructions using a chi-square test. Payer status was grouped into private insurance, government insurance (Medicare or Medicaid), workers' compensation, or self-pay. Two-tailed *t*-tests and Fisher exact tests were used to compare demographic characteristics between patients who had reoperation and those who did not. A multivariable logistic regression model was used to evaluate the association of the demographic characteristics with the chances of having reoperation after flexor pulley reconstruction. Age, sex, concomitant nerve repair, and concomitant flexor tendon repair were entered into the model in a blockwise fashion.

RESULTS

A total of 623 patients met our inclusion criteria for flexor pulley reconstruction between 1998 and 2009. The incidence of flexor pulley reconstruction ranged from 0.18 (2002) to 0.35 (2007) per 100,000 persons, with an incidence of 0.27 per 100,000 persons and frequency of 52 (SD, 11; range, 35 to 68) procedures per year over a 12-year period (Fig. 1). Among all patients who had flexor pulley reconstruction, the mean age was 41 years (SD, 19; range, 7 to 90 y), 39% were female, 9% had a concomitant nerve procedure, 15% had a concomitant flexor tendon procedure, and 17% were insured by a workers' compensation plan. Index procedures were performed at 138 different facilities by 271 different surgeons. Forty percent of cases were performed by surgeons who did at least 5 pulley reconstructions during the study period, and 35% of cases were performed by surgeons who did between 2 to 4 cases. Twenty-five percent of cases were done by surgeons who performed the operation once during the 12-year study period.

There were 39 reoperations (6%) during the study period. The majority of the reoperations were tenolysis (25 of 39; 64%). Nine patients had a repeat reconstruction, and 5 patients had both a tenolysis and a repeat reconstruction. Three patients had 2 reoperations (2 had 2 tenolyses after their index procedures, and one had a tenolysis followed by a repeat reconstruction). The mean time from index surgery to the first reoperation was 33 weeks (range, 3 wk to 2.7 y). Nearly all (40 of 42) of the subsequent procedures were done by the surgeon who performed the index reconstruction.

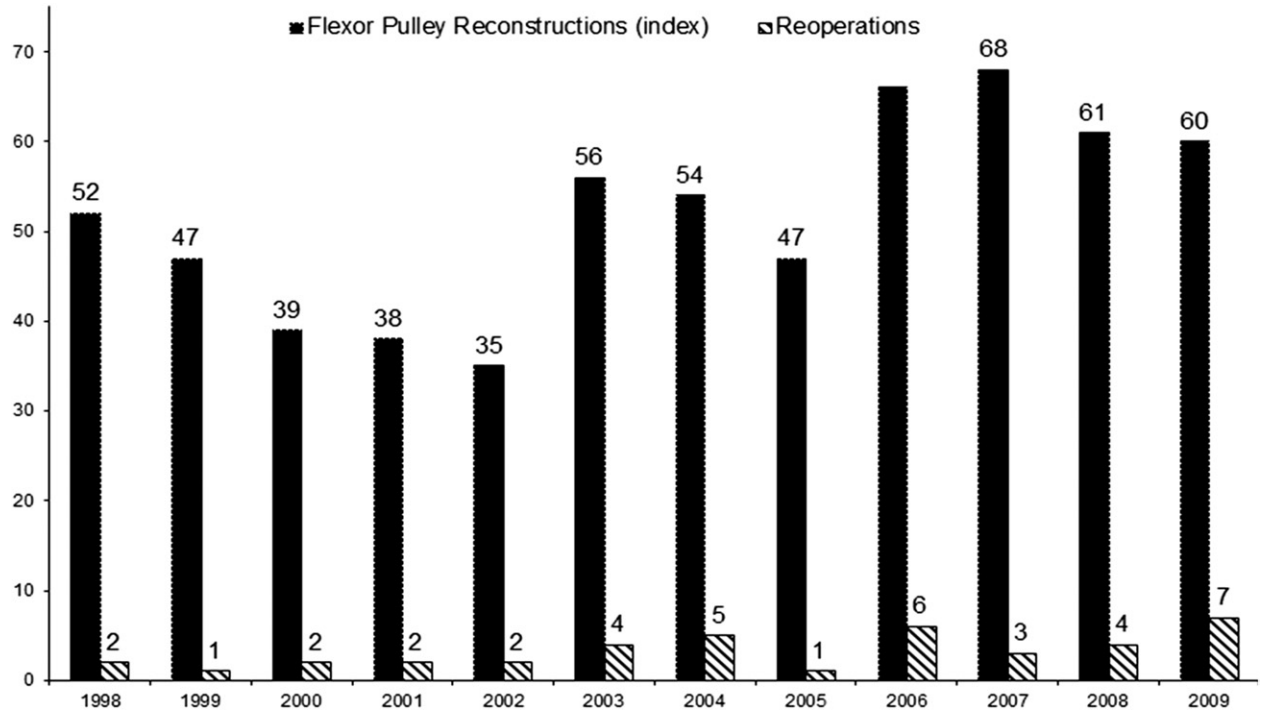

FIGURE 1: Graph demonstrating the number of flexor pulley reconstructions (and subsequent reoperations) performed in each year of the study period.

TABLE 1. Univariate Comparison Between Groups With and Without Reoperation

	No Reoperation (n = 584)	Reoperation (n = 39)	*P* Value
Age	41	38	.39
Male sex	60% (348)	82% (32)	.01
Concomitant nerve repair	8% (48)	15% (6)	.14
Concomitant flexor tendon repair	15% (88)	21% (8)	.36
Primary payer			
Workers' compensation	17% (99)	26% (10)	
Government (Medicare/ Medicaid)	20% (116)	13% (5)	
Private insurance	50% (291)	56% (22)	
Self-pay	5% (28)	0% (0)	

TABLE 2. Results of Logistic Regression for Risk of Reoperation

	Odds Ratio	95% CI	*P* Value
Age	1.0	(0.98, 1.02)	.96
Sex (M vs F)	3.0	(1.2, 7.1)	.01
Concomitant nerve repair	1.6	(0.6, 4.4)	.34
Concomitant flexor tendon repair	1.1	(0.5, 2.7)	.78

Univariate analysis

Men were more likely to have reoperation than women ($P = .006$; Table 1). Patients having reoperation were slightly younger, slightly more likely to have had concomitant procedure, and slightly more likely to have workers' compensation as the primary payer, but none of these differences approached statistical significance. There was no difference in the rate of reoperation among surgeons with case volumes of 5 or more, 2 to 4, or 1 during the study period.

Multivariable regression analysis

There was a significantly higher likelihood among men of having a reoperation compared to women, after adjusting for age, concomitant nerve repair, and concomitant flexor tendon repair. No other variables were significantly associated with increased likelihood of reoperation within the regression model (Table 2).

TABLE 3. Previous Studies of Flexor Pulley Reconstruction

Author (Year)	No. of Cases	Age (Mean) Sex M:F	Mechanism (n)	Finger (n)	Pulley (n)	Diagnosis	Repair Technique (n)
Arora et al (2007)	23	24–59 (40) 20:3	Rock climbing (15) Opening (5) Lifting (3)	Middle (17) Ring (6)	A2 (14) A2, A3 (9)	Clinical, US, and MRI bowstringing	A—Extensor retinaculum (13) B—Nonencircling palmaris longus (10)
Kaufmann et al (2006)	1	48 1:0	Iatrogenic—trigger finger release (1)	Index (1)	A2 (1)	Clinical and MRI bowstringing	Encircling palmaris longus (1)
Voulliaume et al (2004)	12	21–41 (28) 9:3	Rock climbing (12)	Middle (4) Ring (8)	A2 (10) A2, A3 (2)	Clinical and CT bowstringing	Extensor retinaculum (12)
Gabl et al (2000)	6	19–48 (40) 5:1	Rock climbing (3) Lifting (3)	Middle (5) Ring (1)	A2, A3 (6)	Clinical, US, and MRI bowstringing	Extensor retinaculum (6)
Gabl et al (1998)	5	20–51 (32) 5:0	Rock climbing (5)	Middle (4) Ring (1)	A2, A3 (3) A2, A3, A4 (2)	Clinical and MRI bowstringing	Nonencircling palmaris longus (5)
Lin (1999)	1	35 1:0	Degloving injury (1)	Middle (1)	A2 (1)	Intraoperative visualization	3-loop technique (1)
Bowers et al (1997)	7	28–59 (44) 7:0	Rapid extension force (7)	Middle (1) Ring (5) Small (1)	A2, A3, A4 (7)	Clinical bowstrining (7), MRI (4), tenogram (1)	Lateral scar (3) Lateral scar + extensor retinaculum (1) Palmaris longus (1) Extensor retinaculum (1) Flexor digitorum superficialis (1)
Tropet et al (1990)	1	21 1:0	Rock climbing (1)	Ring (1)	A2 (1)	Clinical bowstringing	Primary repair (1)
Okutsu et al (1987)	6	9–38 (25) 4:2	Iatragenic: GCTS excision (1) Tendon grafting (5)	Index (1) Ring (1) Not specified (4)	A2 (4) A2, A3, A4 (2)	N/R	3-loop technique: Palmaris (5) Plantaris/flexor carpi radialis (1)
Total	62	9–59 (36) 53:9	Rock climbing (36) Extension moment (18) Iatragenic (7) Degloving (1)	Middle (32) Ring (23) Index (2) Small (1) Not specified (4)	A2 (31) A2, A3 (20) A2, A3, A4 (11)		Extensor retinaculum (32) Nonencircling palmaris longus (16) Nonencircling other (5) Encircling technique (8) Primary repair (1)

CT, computed tomography; DIP, distal interphalangeal joint; GCTS, giant cell tumor of tendon sheath; MCP, metacarpophalangeal joint; MRI, magnetic resonance imaging; N/R, not recorded; PIP, proximal interphalangeal joint; ROM, range of motion; US, ultrasound; VAS, visual analog scale.

TABLE 3. (Continued)

Preoperative Assessment	Follow-Up (range)	Postoperative Motion/Strength	Function	Ability	Complications
A—PIP flexion: 82 B—PIP flexion: 80	A—48 mo (18–43) B—57 mo (16–48)	A—PIP flexion: 91 (97%) Power grip: 48 kg (96%) Pinch strength: 8 (100%) Circumference: 70 mm (94%) B—PIP flexion: 91 (94%) Power grip: 48 kg (98%) Pinch strength: 7 (100%) Circumference: 62 mm (94%)	Buck Gramcko: A— 10 excellent 2 good 1 fair B— 7 excellent 2 good 1 fair	All climbers returned to climbing, others to work. All would have procedure again.	None reported
MCP ROM: 0–45 PIP ROM: 0–80 DIP: 0–40 Grip strength: 70%	20 mo	MCP ROM: 0–75 PIP ROM: 0–80 DIP: 0–40 Grip strength: 70%	N/R	Returned to guitar/ piano	None reported
N/R	12 mo	N/R	Self-report: 9 excellent 2 good 1 fair	Climbing relative to pre-injury levels: 5 superior 5 equivalent 2 inferior	Clinical bowstringing with pain (2)
VAS pain: 35 PIP flexion: 27 Pinch grip: 28N Circumference: 76 mm	19.5 mo (29–48)	PIP flexion: 116 Pinch grip: 56N Circumference: 71 mm	VAS pain: 7	All climbers returned to climbing, others to work. All would have procedure again.	None reported
N/R	27 wk (18–40)	PIP motion: reduced 4 Grip strength: reduced 12N Circumference: increased 4.8 mm	Subjective rating: 5 excellent Pain: 4 pain free 1 pain at high load	All returned to climbing at preinjury levels	Clinical bowstringing (1)
N/R	10 y	Motion: Improved at 27 mo Reduced at 6 y	N/R	N/R	Hourglass-shaped bone resorption around phalanx
PIP ROM: 64–106 DIP ROM: 0–50	5.3 y (0.5–12)	PIP ROM: 4–105 DIP ROM: 3–47	N/R	N/R	None reported
DIP ROM: 0–20	6 mo	DIP ROM: 0–70	N/R	N/R	None reported
MCP + PIP + DIP ROM: 175 Tip-palm distance: 32 mm	21 mo (9–36)	MCP + PIP + DIP: 205 Tip-palm distance: 22 mm	N/R	All reported satisfactory grip function	None reported
					Bowstringing (3) Pain (2) Bone resorption (1)

DISCUSSION

We used population-based data to describe the incidence of flexor pulley reconstruction and the frequency of reoperation after flexor pulley reconstruction (6%). Compared to flexor tendon repair,[15] flexor pulley reconstruction is much less commonly performed. Annually, an average of 52 flexor pulley reconstructions were performed in New York, compared to an average of 602 flexor tendon repairs.[15] As expected, surgeons are much less likely to encounter flexor pulley reconstruction in practice. One-quarter of surgeons performed the surgery only once during the 12-year study period. We did not find a difference in reoperation rate based on surgeon volume for this procedure. The current study provides a better understanding of the relative infrequency of flexor pulley reconstruction, which may be useful in planning postgraduate training and continuing medical education.

The reoperation rate following flexor pulley reconstruction is the same as the reoperation rate following flexor tendon repair found using similar methodology.[15] The reoperation rates are likely reflective of the level of technical challenge and surgical principles demanded by both procedures. The mean time to reoperation was longer for flexor pulley reconstruction (232 days) than for flexor tendon repair (140 days). Our findings may be useful to hand surgeons when counseling patients about their likelihood of requiring reoperation when planning for their flexor pulley procedure.

Our ability to place our findings in the context of the existing literature is limited by the small number of published case reports and series, which are summarized in Table 3. We found 62 isolated flexor pulley reconstruction outcomes in our literature review.[1–4,6–9] Consistent with our findings, the mean age of the patients was 36 years, with men comprising a majority (85%). The literature indicates that a preponderance of flexor pulley injuries resulted from rock climbing injuries (58%), involved the middle finger (52%), and were isolated to the A2 pulley (50%). In our study, there was a decrease in the frequency of flexor pulley injuries from 1998 to 2002, which was followed by an overall increase, particularly in the last 4 years of the study period (Figure 1). Although we do not have information on cause of injury in our data, we speculate that the increase in flexor pulley injuries may be related to the growth of rock climbing as a recreational activity in the United States, with 6 million Americans over the age of 6 years old participating in the activity[20] in 2009. The most commonly reported technique was a nonencircling reconstruction using extensor retinaculum autograft (52%), similar to the technique attributed to Weilby.[21] The generally positive clinical outcomes (satisfaction, grip/pinch strength, and range of motion) reported in these series suggest that the vast majority of patients did well. Adverse outcomes were reported in 4 patients (6%), including recurrence of clinical bowstringing[6,9] in 3 and bone erosion[3] in 1. None of the patients sustaining these complications were explicitly reported by the authors as having had reoperation. However, when pulley reconstruction has been performed in conjunction with flexor tendon repair, complications such as swan-neck deformity with graft-induced articular wear[22] and repeat operations for tenolysis and infection[23] have been reported. We did not find a significant difference in reoperation risk if concomitant flexor tendon repair was performed, but this may be attributable to the relative infrequency of reoperation. It is possible that the paucity of information about complications following flexor pulley reconstruction may be due to publication bias, reflecting a lower enthusiasm to report complications. The discrepancy between the literature and our population-based estimate of revision (6%) may suggest a possible volume-outcomes benefit, in that surgeons who perform the procedure frequently enough to report their findings may have a lower complication risk than all surgeons who performed flexor pulley reconstruction in New York during the study period.

The risk of stiffness after flexor pulley reconstruction is neither well described nor well understood. Our finding that the majority of reoperations included tenolysis suggests that inadequate tendon gliding is a major potential complication after flexor pulley reconstruction. However, this is not substantiated by the limited clinical literature. Both Gabl[7] and Arora[8] have reported excellent recovery of proximal interphalangeal joint motion at mean follow-up times of 20 months and 57 months, respectively. This discrepancy may be related to the type of reconstructive technique used, as both Gabl and Arora used techniques that did not encircle the phalanx (as opposed to the loop reconstructions popularized by Okutsu[5]). Although our available data do not contain the level of detail needed to compare this risk between reconstruction techniques, this may be appropriate for future clinical investigation, given the relative advantages and disadvantages of each technique.[12–14]

The main limitations of the current study are those inherent to the use of large administrative or claims databases. Clinical outcomes are not available from administrative data, which prevents us from drawing upon the large sample size of our study to examine parameters such as range of motion, recovery of function, and patient satisfaction. The administrative data do

not provide the original indications for flexor pulley reconstruction. We are unable to capture whether pulley reconstructions were originally performed as a consequence of intentional or unintentional pulley compromise during flexor tendon repair. Although we attempted to account for injury severity by including concurrent nerve repair and tendon repair in our analysis, our methods may not have fully captured the influence of injury severity on postoperative complications. In addition, we were unable to understand the circumstances surrounding the decision to have a second surgery. Different surgeons have varying thresholds for offering reoperation, and individual patients have varying levels of willingness to have repeat surgery. Finally, we were limited to only outpatient surgery data for this report. Our experience with this database indicates that we cannot confidently identify flexor apparatus procedures from the available inpatient data. It is possible that additional index flexor pulley reconstructions were performed, but we expect that the majority of these procedures were done on an outpatient basis. Patients may have had reoperation outside New York and would not be captured by our database.

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