

# The Epidemiology of Reoperation After Flexor Tendon Repair

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**Purpose** To describe the incidence of reoperation and the demographic factors that may be associated with reoperation after flexor tendon repair.

**Methods** Using a New York statewide hospital administrative database covering an 8-year period, we examined unique patient discharges with an index procedure of flexor tendon repair for reoperation (re-repair or tenolysis). We compared the age, sex, race, and insurance type by reoperation status using standard univariate statistics and multivariate regression analysis. We performed trend analysis using the Cochran-Armitage trend test.

**Results** From 1998 to 2005, there were 5,229 flexor tendon repairs with a frequency of reoperation of 6%; of these, 91% were in the first year after the primary procedure. Those who underwent reoperation were significantly older than those who did not undergo reoperation. Patients with workers' compensation were 63% more likely to undergo reoperation than those with other forms of insurance. Patients who had concomitant nerve repair during the index procedure were 26% less likely to undergo reoperation. The rate of reoperation did not change during the study period.

**Conclusions** These results may be useful in shaping research agendas to evaluate sociodemographic factors contributing to reoperations. (*J Hand Surg* 2012;37A:919–924. Copyright © 2012 by the American Society for Surgery of the Hand. All rights reserved.)

**Type of study/level of evidence** Prognostic II.

**Key words** Flexor tendon, outcomes, epidemiology, disparities, socioeconomic.

**A**CUTE FLEXOR TENDON injuries account for less than 1% of hand injuries<sup>1</sup> but represent a substantial burden to both the individual and society, because flexor tendon injuries commonly occur in young, working people. The costs associated with the treatment of flexor tendon injuries include the direct costs associated with surgery and postoperative therapy, as well as the indirect cost of lost productivity. Despite

the intense interest in and study of these injuries, flexor tendon injuries remain challenging to treat.<sup>2</sup>

The evolution of surgical technique, suture material, and postoperative rehabilitation may give the impression that outcomes after flexor tendon repair have improved, but the results are still inconsistent.<sup>3–5</sup> Estimates of the re-repair rate have been as high as 17%,<sup>5–7</sup> whereas fair or poor outcomes have been reported in 7% to 20% of patients after flexor tendon repair.<sup>8,9</sup> Review of the literature suggests that secondary surgery to treat complications after flexor tendon repair is common; nevertheless, the incidence of reoperation in the modern era is not clearly defined. An understanding of the demographics and recent trends in reoperation after flexor tendon repair is a critical first step in understanding why such complications still occur.

Little has been published to describe the incidence of flexor tendon injuries treated surgically,<sup>1</sup> and the rarity

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**TABLE 1. CPT Codes Used**

Primary flexor tendon repair	
26350	Flexor tendon repair or advancement flexor tendon not in zone 2 digital flexor tendon sheath (eg, no man's land); primary or secondary without free graft, each tendon
26356	Flexor tendon repair or advancement, single, in zone 2 digital flexor tendon sheath (eg, no man's land); primary, each tendon
26370	Profundus tendon repair or advancement, with intact sublimis; primary
Secondary flexor tendon repair	
26352	Flexor tendon repair or advancement, single, not in zone 2 digital flexor tendon sheath (eg, no man's land); secondary with free graft (includes obtaining graft), each
26357	Flexor tendon repair or advancement, single, in zone 2 digital flexor tendon sheath (eg, no man's land); secondary, each tendon
26358	Flexor tendon repair or advancement, single, in zone 2 digital flexor tendon sheath (eg, no man's land); secondary with free graft (includes obtaining graft), each
26372	Profundus tendon repair or advancement, with intact sublimis; secondary with free graft (includes obtaining graft)
Flexor tendon tenolysis	
26440	Tenolysis, simple, flexor tendon; palm OR finger, single, each tendon
Digital nerve repair at time of index flexor tendon repair	
64831	Suture of digital nerve, hand or foot; 1 nerve

of these injuries makes it difficult to characterize the epidemiology of reoperation without using population-based data. In the current study, we have used a statewide hospital administrative database to determine the incidence of reoperation after flexor tendon repair, analyze recent trends in reoperation, and describe the demographic characteristics that may be associated with the need for reoperation. We hypothesized that the rate of reoperation after flexor tendon repair would decrease over the study period and that financial payer status would not have a significant association with reoperation rate.

## MATERIALS AND METHODS

The Statewide Planning and Research Cooperative System (SPARCS) database from the New York State Department of Health is a census of all statewide hospital admissions and ambulatory surgery procedures. The database has been operational since 1982 and contains more than 20 years of hospital discharge data for New York state. Unique patient identifiers, which allow a single patient to be tracked anonymously irrespective of hospital or treating surgeon, were made available starting in 1997. The SPARCS database has been used in previous research on the frequency of and complica-

tions from a variety of orthopedic surgical procedures.<sup>10–13</sup>

This study used SPARCS records from 1998 through 2005 to identify New York State residents of all ages treated with flexor tendon repairs. Patients were observed through the end of 2006, the latest data we had available that allowed a minimum of 1-year follow-up for all identified patients. Data were not available beyond this time period. The first admission for each patient with a flexor tendon repair was considered the index procedure, unless the procedure included tenolysis. All patients were monitored via their records for subsequent admissions for reoperation (re-repair, reconstruction, or tenolysis) (Table 1). The CPT4 codes used for flexor tendon repair were 26350, 26356, 26370, 26352, 26357, 26358, and 26372. The following CPT4 codes were used for flexor tendon tenolysis: 26440 and 26442. The number and timing of each procedure after the index procedure were recorded. We calculated the incidence of reoperation after primary repair by year of index surgery.

Demographic variables available in the database include age, gender, and payer status. Payer status was categorized as government-funded (Medicare or Medicaid), private, self-pay, or workers' compensation.

**TABLE 2. Descriptive Statistics and Univariate Comparisons for All Patients (1998–2005)**

	No Reoperation (n = 4,911)	Reoperation (n = 318)	P Value
Age (mean ± SD)	33.8 ± 15.9	37.4 ± 16.2	.013
Female	1,457 (30%)	99 (31%)	.583
Concomitant nerve repair	1,241 (25%)	64 (20%)	.045
Primary payer			
Workers' compensation	764 (16%)	69 (22%)	.004
Government	950 (19%)	48 (15%)	.061
Private insurance	2,599 (53%)	172 (54%)	.682
Self-pay	598 (12%)	29 (9%)	.101

Percentages are calculated using the total number of patients in each group (no reoperation or reoperation) as the denominator.

**TABLE 3. Multivariable Logistic Regression for All Patients (1998–2005)**

	OR (95% CI) (N = 5,229)	P Value
Age (y)		
<16 (prework)	Reference	.010*
16–24 (early work)	1.16 (0.69, 1.93)	
25–44 (midwork)	1.42 (0.89, 2.29)	
45–64 (late-work)	1.65 (1.00, 2.72)	
65+ (retirement)	1.77 (0.91, 3.47)	
Female	1.11 (0.86, 1.42)	.500
Concomitant nerve repair at index procedure	0.74 (0.55, 0.98)	.040
Workers' compensation	1.63 (1.23, 2.17)	.010

OR, odds ratio.  
\*Test for trend.

Multiple payers were recorded for each patient if present, and primary payer status was determined by SPARCS coding as reported by the hospitals. Concomitant digital nerve repair at the time of index flexor tendon repair (Current Procedural Terminology 4 code: 64831) was recorded.

We compared the age, sex, nerve repair status, and insurance type for patients with a reoperation with those without a reoperation using standard univariate statistical tests, including Student's *t*-test, Fisher's exact test, and Kruskal-Wallis test. We created a multivariate logistic regression model to evaluate the association of these covariates with the likelihood of reoperation. The covariates (age, sex, nerve repair status, and insurance status) were entered in a blockwise fashion. We performed trend analysis to evaluate for changes in reoperation frequency over the study's time period using the Cochran-Armitage trend test.

**RESULTS**

**Descriptive results**

Between 1998 and 2005, 5,229 patients met our inclusion criteria for first flexor tendon repair. Nerve repair was performed in 1,305 (25%) of flexor tendon repairs. The overall frequency of reoperation in these patients was 6% (N = 318). Tenolysis alone, re-repair alone, and tenolysis with re-repair were performed in 58% (186 patients), 38% (121 patients), and 4% (11 patients) of reoperations, respectively. The majority of patients (294; 92%) who had secondary surgery had only 1 reoperation. A total of 24 patients (8%) had 2 surgeries

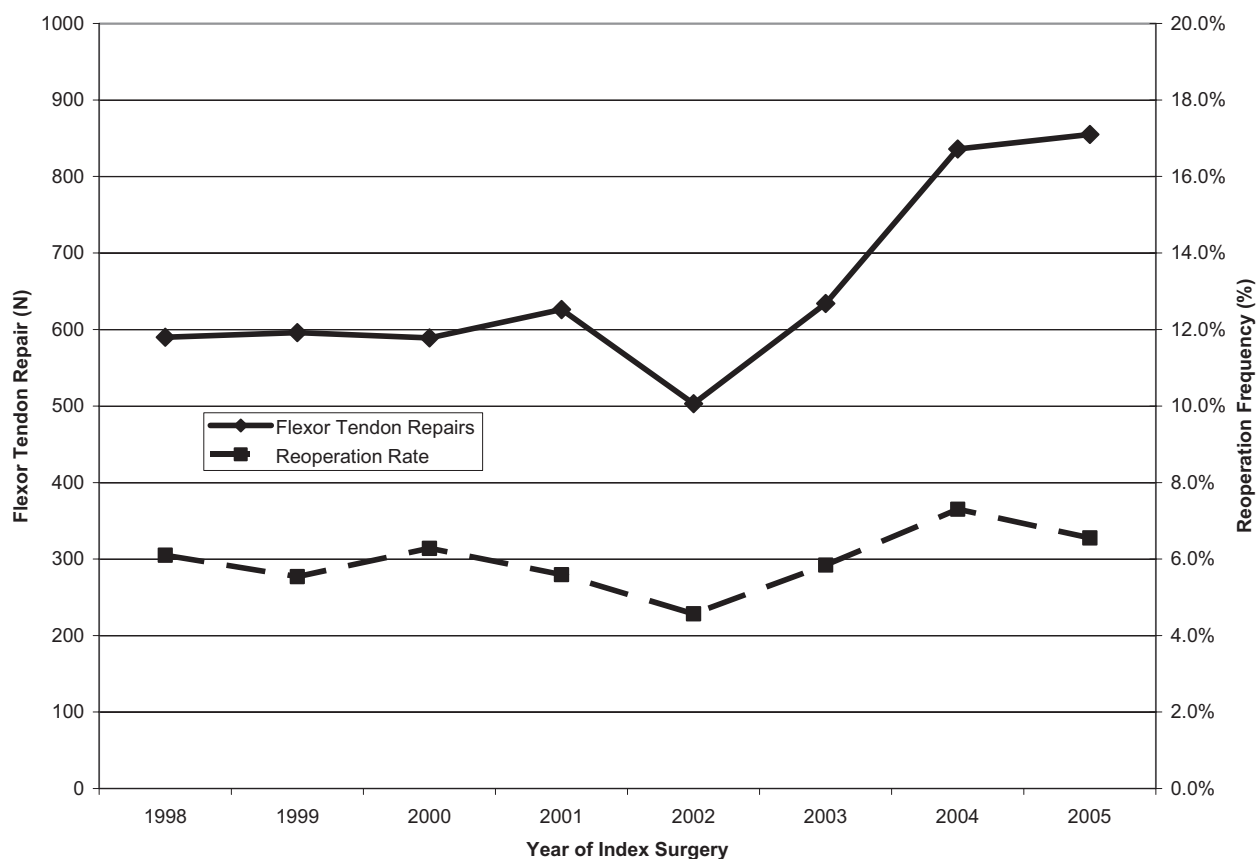
after the primary repair, and 4 patients (1%) had 3 subsequent surgeries. In addition, 91% (290) of reoperations were performed within 1 year after the index procedure (median, 140 d; minimum, 1 d; maximum, 6.7 y). The median time to reoperation was significantly lower when re-repair was performed at reoperation (35 d), compared with tenolysis (183 d) and tenolysis with re-repair (119 d) (*P* < .001; Kruskal-Wallis test).

**Univariate analysis**

Patients who underwent reoperation were older than those who did not, and there was a lower likelihood of any reoperation when concomitant nerve repair was performed at the time of initial flexor tendon repair (Table 2). When specifically evaluating the type of reoperation (re-repair, tenolysis, or re-repair with tenolysis), there was a significantly lower frequency of re-repair when a concomitant nerve repair was performed (*P* = .007). There was no difference in likelihood of tenolysis or re-repair with tenolysis when concomitant nerve repair was performed.

**Multivariate regression analysis**

There was a significantly higher likelihood of undergoing a reoperation when comparing patients in the 45- to 64-year age group with patients less than 16 years of age (Table 3). Patients with workers' compensation were 63% more likely to undergo reoperation than those whose primary payer was government-funded, private insurance, or self-pay (Table 3). Concomitant nerve repair with index procedure was protective of reoperation (Table 3).



**FIGURE 1:** Frequency of flexor tendon repairs and reoperations in each year of the study period.

### Trend analysis

The incidence of reoperation ranged from 5% (23 patients) in 2002 to 7% (61 patients) in 2004 (Fig. 1). There was no statistically significant difference in the frequency of reoperation between the different years of the study period.

### DISCUSSION

In the current study, we used a population-based data source to describe the frequency of secondary surgery (6%) for re-repair or tenolysis after primary flexor tendon repair. Most reoperations performed were tenolysis alone (58%). Patients who had a concomitant nerve repair during the index procedure were 26% less likely to undergo reoperation, which suggests that nerve repair was protective of undergoing reoperation. This may be related to differences in motion protocols used for patients who have had nerve repairs. This finding deserves future investigation that we cannot perform at the epidemiologic level.

The frequency of reoperation from 1997 to 2005 in New York is similar to reported rates of re-rupture ranging from 4% to 6%<sup>14,15</sup> and rates of tenolysis ranging from 0% to 17%.<sup>16–21</sup> Our demographic anal-

ysis revealed that patients who underwent reoperation were older. Our current epidemiologic study is in agreement with prior histopathologic findings showing that advanced age is predictive of tendon nonhealing,<sup>22</sup> and clinical studies showing a correlation between younger age and radiographic healing of tendon repairs.<sup>23,24</sup>

Patients with workers' compensation as a primary payer were 48% more likely to undergo reoperation than those with any other type of primary payer. Previous investigation by Day and colleagues<sup>25</sup> has shown patients with workers' compensation to be more likely to undergo surgery and significantly more likely to require more office visits before surgery than patients with private insurance. It is possible that higher injury severity could be sustained during work or that the substantial disability associated with poor outcomes after flexor tendon repair may contribute to the higher rates of reoperation seen for workers' compensation patients in our population.

There was no improvement in outcomes as measured by frequency of reoperation over the study period. This absence of improvement exists despite the considerable amount of resources invested in flexor tendon research, touted to be one of the most frequently published topics

in the orthopedic surgery literature.<sup>2</sup> One possibility is that although hand surgeons are learning and implementing new advanced techniques thought to improve outcome, these adaptations are not translating into clinical improvement. Alternatively, it is possible that information learned from the copious body of flexor tendon literature is not being translated into clinical practice. Both scenarios present interesting avenues for further study on research resource allocation and education in hand surgery. The study period may have been too short to identify any differences in outcome if they do in fact exist.

The strengths of this study include the use of a large statewide hospital administrative database over an 8-year period. We were able to track individual patients who received treatment within the state of New York. Although patients who experienced poor outcomes or reoperations may have sought treatment at an out-of-state facility, we restricted the cohort to patients who were New York State residents at the time of their primary surgery, reducing the chance that this patient population would receive subsequent treatment outside New York State. In addition, this limitation is more likely to lead to a more conservative estimate of reoperation after flexor tendon repair if complications were treated out of state.

The main limitations of this study are those associated with the use of any large administrative or claims data. Race was missing for a large number of patients because this is a voluntary reporting field. Unlike previous studies using administrative databases for orthopedic research, the likelihood of the reoperations being performed on the contralateral limb are extremely unlikely, although that possibility exists. Another limitation is that the decision to reoperate was based on a number of individual and subjective factors that cannot be captured by administrative data. We were unable to characterize the contribution of financial incentive to the physician or patient in their willingness to offer or undergo reoperation, respectively. This limitation is of special note when interpreting our results related to workers' compensation patients.<sup>25,26</sup>

The diagnosis of re-rupture or stiffness is challenging after initial flexor tendon repair, and each surgeon has a specific threshold to reoperate based on prior experiences. Although biological and clinical factors contribute heavily to a surgeon's decision to reoperate, further evaluation of sociodemographic factors may be useful in shaping research agendas to minimize reoperations after flexor tendon repair. Future study is needed to investigate this rise in view of the consider-

able allocation of resources toward research in flexor tendon repair.

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