



# Hand therapy utilization following digital flexor tendon repair: Trends, timing, predictive factors, and association with reoperation



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## ABSTRACT

**Background:** Physical rehabilitation is considered an important component of recovery following digital flexor tendon repair (FTR), but no studies have thoroughly characterized nationwide therapy utilization in the United States.

**Purpose:** The current study characterized national trends in the timing and amount of hand therapy utilization following FTR and assessed factors associated with the lack of postoperative hand therapy.

**Study Design:** Retrospective cohort study.

**Methods:** Zone II FTRs between 2010 and 2020 were identified in PearlDiver. Exclusion criteria included age < 18 years, concomitant procedures besides nerve repair, and follow-up in the database of < 6 months. The occurrence, timing, and frequency of hand therapy within 6 months of surgery were identified. Odds of not receiving hand therapy were assessed based on clinical and nonclinical characteristics using logistic regression.

**Results:** Of 6700 FTRs identified, hand therapy was identified for 3319 (50%). The proportion of patients utilizing therapy increased from 2010 to 2020 (44%–56%,  $p < 0.001$ ). Weekly therapy utilization peaked in postoperative week 4 (41% of all patients attended hand therapy). Lack of hand therapy utilization was associated with several clinical factors (male sex, lower Elixhauser Comorbidity Index score, decreasing number of repairs) and nonclinical factors (geographic region, Medicare insurance).

**Conclusions:** Despite the reported importance of hand therapy following digital FTR, it may be underutilized in the United States. Patient factors associated with not using hand therapy suggest that more uniform clinical practice should be sought.

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## Introduction

Digital flexor tendon repairs (FTRs) in zone II are a well-known technical and rehabilitative challenge due to the complex anatomy in this part of the hand—narrow fibro-osseous digital canal, neighboring pulleys, and close association of flexor digitorum superficialis and flexor digitorum profundus tendons—and adhesion formation postoperatively.<sup>1–3</sup> Flexor tendon injuries commonly occur in zone II and several reports suggest that hand therapy with defined protocols is an important component of postoperative rehabilitation following FTR, as mobilized tendons heal faster and stronger.<sup>3–6</sup> Early motion

protocols, relative to immobilization, have been shown to reduce adhesion formation, increase tensile strength, improve gliding function, and achieve greater total active motion.<sup>7</sup>

Although the value of postoperative hand therapy is well-established for FTR, utilization of and factors associated with hand therapy are not fully defined. Several single-institution studies have considered the rates of hand therapy utilization and factors associated with its use following FTR. These studies indicate that most patients utilize hand therapy following surgery and identify demographic and socioeconomic factors related to reduced therapy attendance and adherence, such as race, insurance coverage, employment status, and high social deprivation.<sup>8–10</sup>

The aforementioned, single-institution studies identified important factors to consider with regard to disparate hand therapy utilization, but they provide an incomplete picture of hand therapy utilization on a national level and over time. The present study aimed to characterize trends in the timing and amount of hand

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therapy utilization following FTR and assess factors associated with the lack of postoperative hand therapy. Examining the utilization of hand therapy on a national level provides a more comprehensive look at hand therapy utilization in the United States, allowing surgeons and therapists to identify gaps in postoperative rehabilitation and improve patient adherence and outcomes.

## Methods

The current study analyzed data from the M161Ortho PearlDiver Mariner Patient Claims Database, which contains administrative data on more than 100 million patients across the United States from 2010 to 2021 and has been previously used for the study of postoperative hand therapy (PearlDiver Technologies, Colorado Springs, CO).<sup>11–13</sup> The institutional review board has granted an exemption for PearlDiver studies because all data are output in a deidentified, aggregated format. Study cohorts, hand therapy visits, and reoperations were identified using Current Procedural Terminology codes (Appendix A).

Patients with zone II FTR were identified. Patients younger than 18 years of age, with < 1 year of database follow-up, and with concomitant digital FTRs outside of zone II were excluded. All other procedures occurring on the same day of zone II FTR were identified and manually reviewed. Patients with any other hand or upper extremity procedures besides nerve repair were excluded (eg, vascular injury, fracture, dislocation, and amputation). Patients were then stratified by postoperative hand therapy utilization, which was defined by the presence of an evaluation by an occupational therapist or physical therapist within 6 months of surgery.

The annual proportion of patients utilizing postoperative hand therapy from 2010 to 2020 was determined for the entire cohort and by insurance coverage. The time from surgery to initial hand therapy evaluation for each patient was determined. Within 6 months of surgery, the total number of hand therapy visits and the number of patients visiting hand therapy in each postoperative week were determined. Individual hand therapy visits were identified by the presence of an occupational or physical therapy evaluation or a code denoting an intervention by a therapist.

Patient characteristics were identified for the assessment of factors associated with lack of postoperative hand therapy utilization. Clinical characteristics included age, sex, and Elixhauser Comorbidity Index (ECI) score. ECI was designed to control for comorbidities in analyses of administrative data by accounting for more than 30 comorbidities, including cardiovascular disease and diabetes.<sup>14</sup> The ECI score is calculated by summing the number of covered comorbidities for each patient. The number of tendons repaired was determined by summing the number of Current Procedural Terminology codes for primary zone II FTR billed on the day of surgery. Patients with concomitant nerve procedures were identified. Nonclinical characteristics included geographic region (United States Census Bureau definitions of Midwest, Northeast, South, and West), insurance coverage (commercial, Medicaid, Medicare), and mean family income (based on the patient's zip code of residence).

Reoperations were identified within 1 year of surgery to assess the association of hand therapy utilization with reoperations. Reoperations for rupture included revision repair and tendon transfer. Reoperations for stiffness included tenolysis, tenotomy, and capsulectomy.

Statistical analysis was performed within the PearlDiver interface, which utilizes R (R Foundation for Statistical Computing, Vienna, Austria). Annual trends in postoperative hand therapy utilization were assessed using simple linear regression and chi-squared tests (comparing 2010–2020). Patient and procedural characteristics between patients with and without postoperative hand therapy utilization were compared using *t*-tests (age, ECI score,

mean family income) and chi-squared tests (sex, geographic region, insurance coverage, number of tendon repairs, and number of patients with concomitant nerve procedures).

Factors associated with lacking postoperative hand therapy utilization were assessed using multiple logistic regression. The dependent variable was the lack of postoperative hand therapy evaluation, and the independent variables were age, sex, ECI score, geographic region, insurance coverage, mean family income, number of tendon repairs, and the presence of concomitant nerve procedures. Results are reported as odds ratios (ORs) with 95% confidence intervals (95CI) and *p*-values.

The association of hand therapy utilization with reoperations for rupture or stiffness was assessed using multiple logistic regression, in which the dependent variable was reoperation and the independent variables were hand therapy utilization, age, sex, ECI score, geographic region, insurance coverage, mean family income, number of tendon repairs, and the presence of concomitant nerve procedure. Results are reported as OR, 95CI, and *p* values.

## Results

The final study cohort consisted of 6700 adult patients who underwent zone II FTR (isolated or in conjunction with nerve repair) with at least 6 months of postoperative follow-up. Of these patients, 3319 (50%) had a hand therapy evaluation within 6 months of surgery, and 3381 (50%) had no recorded evaluation (Fig. 1).

Figure 2 shows the annual proportion of patients utilizing hand therapy from 2010 to 2020. The proportion of patients utilizing hand therapy increased from 2010 to 2020 (44%–56%,  $p < 0.001$ ). Hand therapy utilization improved to the greatest degree for patients with Medicaid insurance (25%–62%,  $p = 0.001$ ), followed by those with commercial insurance (47%–58%,  $p < 0.001$ ) and Medicare (38%–51%,  $p = 0.288$ ).

For patients who utilized postoperative hand therapy, the mean (standard deviation) time from surgery to hand therapy evaluation was 18 days (34). The median (interquartile range) time from surgery to evaluation was 9 days (15) with a range of 1–138 days. Within 6 months of surgery, the mean (standard deviation) number of hand therapy visits was 13 (11). The median (interquartile range) number of visits was 11 (14) with a range from 1 visit to 73 visits. There were 1483 (22%) patients with 1–9 visits, 1076 (16%) with 10–19 visits, 479 (7%) with 20–29 visits, and 281 (4%) with 30 or more visits (Fig. 2). Evaluating weekly hand therapy visits revealed peak utilization in weeks 4 and 5, in which 41% of the entire FTR cohort had an encounter with a therapist (Fig. 3).

Table 1 shows characteristics of patients with and without postoperative hand therapy utilization. On univariate analysis, there was no difference in mean age (44 years vs 44 years,  $p = 0.161$ ). The cohort without hand therapy included more men (61% vs 57%,  $p < 0.001$ ) and had a greater mean ECI score (3 vs 2,  $p = 0.015$ ) than the cohort with hand therapy. Significant differences in geographic region ( $p < 0.001$ ) and insurance coverage ( $p < 0.001$ ) were observed, with Medicare patients being more likely to miss therapy and commercial patients being less likely. The cohort without hand therapy lived in locations with lower mean family income ( $p = 0.028$ ) and included fewer patients with multiple tendon repairs ( $p < 0.001$ ) and fewer patients with concomitant nerve procedures ( $p = 0.016$ ).

Multivariate analysis of factors associated with a lack of postoperative hand therapy revealed several significant factors (Table 2). Clinical factors associated with greater odds of lacking postoperative hand therapy included male sex (OR 1.20,  $p < 0.001$ ), lower ECI score (OR 1.02,  $p = 0.039$ ), and fewer tendon repairs (compared to patients with four or more repairs, those with one [OR 2.02,  $p < 0.001$ ] or two [OR 1.54,  $p = 0.002$ ]). Nonclinical factors associated with greater odds

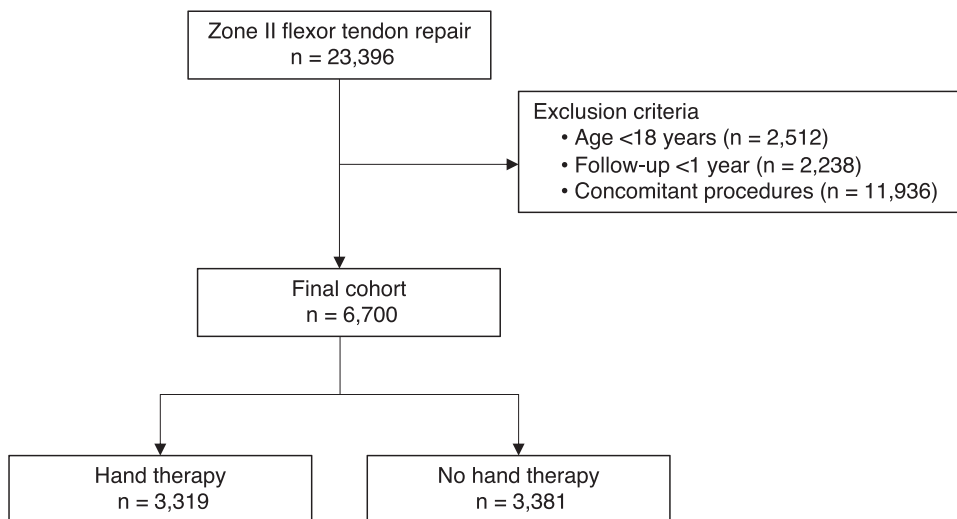


Fig. 1. Flow diagram showing the designation of study cohorts.

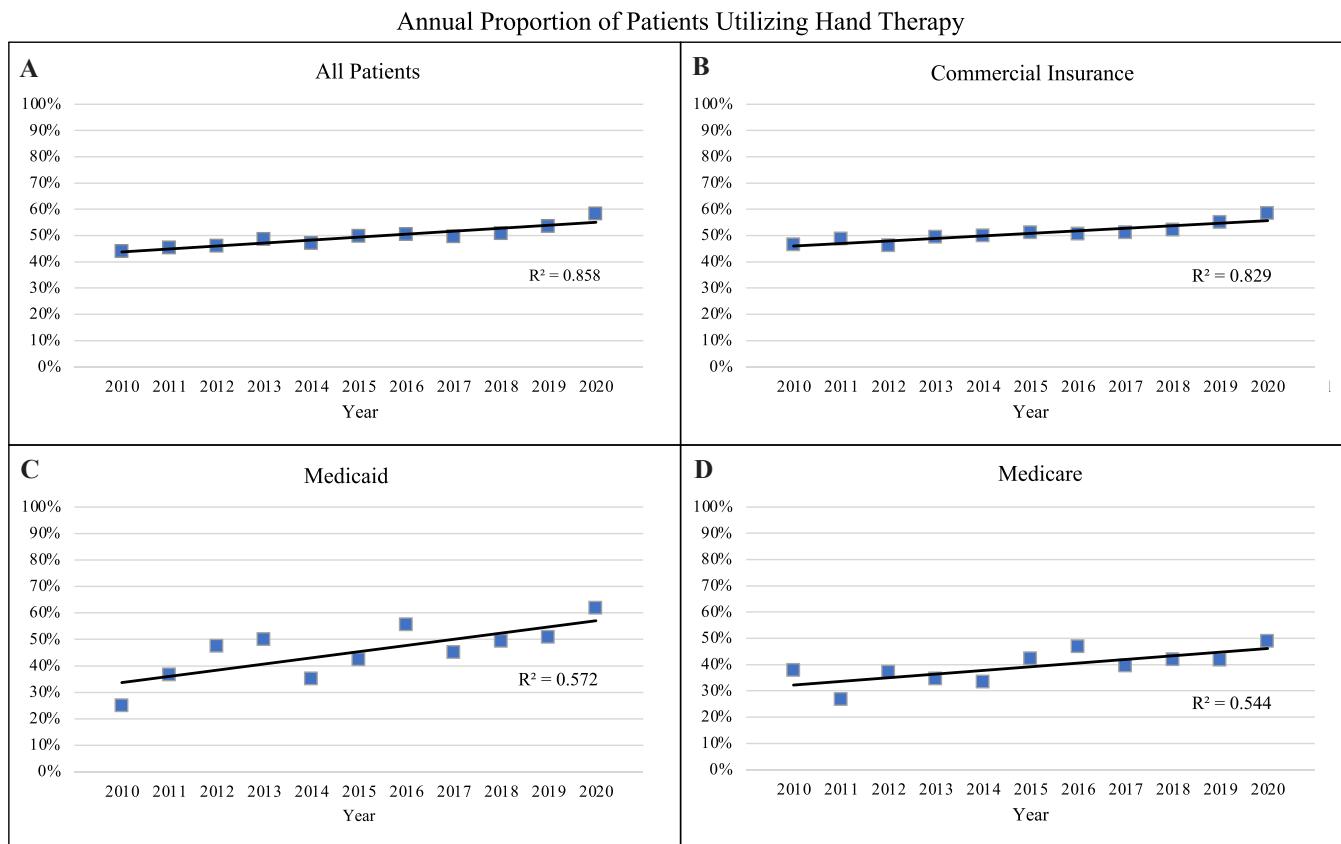
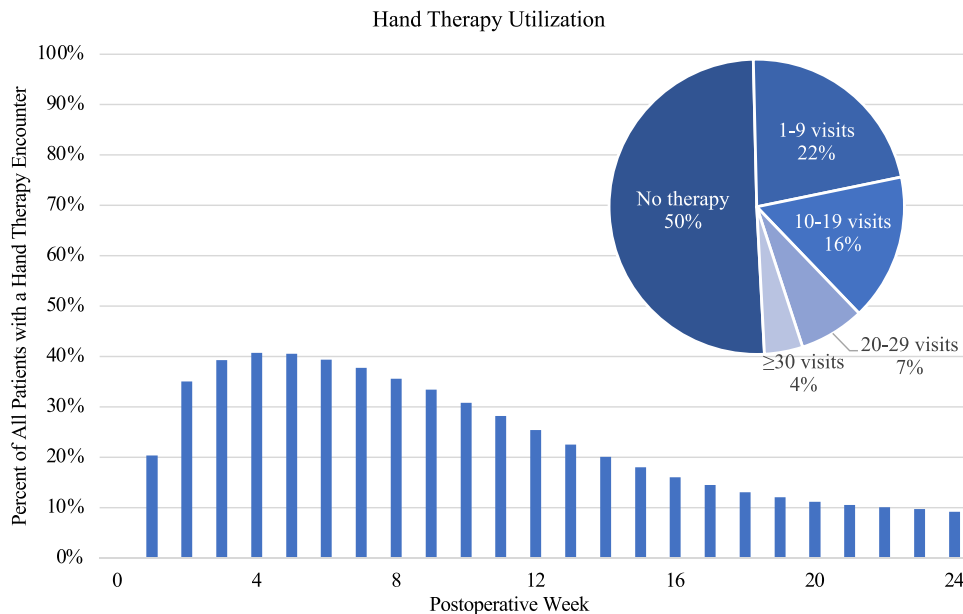


Fig. 2. Proportion of patients utilizing postoperative hand therapy by year broken down by insurance coverage: all patients (A), patients with commercial insurance (B), patients with Medicaid (C), and patients with Medicare (D). R-squared from simple linear regression is shown for each plot.

of lacking postoperative hand therapy included geographic region (compared to patients in the Midwest, Northeast [OR 1.27,  $p = 0.005$ ], South [OR 1.48,  $p < 0.001$ ], and West [OR 1.69,  $p < 0.001$ ]) and insurance coverage (compared to patients with commercial insurance, Medicare [OR 1.65,  $p < 0.001$ ]). Age ( $p = 0.770$ ), Medicaid ( $p = 0.297$ ), mean family income (0.054), and concomitant nerve procedures ( $p = 0.400$ ) were not significant in multivariate analysis.

Within 1 year of FTR, 140 (4.2%) patients with hand therapy underwent reoperation for tendon rupture, and 94 (2.8%) patients without hand therapy underwent reoperation for tendon rupture (OR 1.53, 95CI 1.14–2.07,  $p = 0.005$ ) (Fig. 4). Reoperations for stiffness were identified for 281 (8.5%) patients with hand therapy and 189 (5.6%) patients without hand therapy (OR 1.48, 95CI 1.20–1.83,  $p < 0.001$ ).



**Fig. 3.** Proportion of all patients (with or without postoperative hand therapy) with a hand therapy visit in each postoperative week (*bar graph*). The proportion of patients with no visits, 1-9 visits, 10-19 visits, 20-29 visits, and 30 or more visits within 6 months of surgery.

## Discussion

The current study of 6700 zone II FTRs across the United States describes recent trends in the utilization of hand therapy, characterizes the timing and amount of hand therapy, and identifies factors associated with hand therapy utilization, as well as the association of hand therapy with reoperation.

Overall rates of hand therapy utilization were low, with about half of patients undergoing evaluation by a therapist within 6 months of surgery. This number is significantly lower than would be expected given the support for hand therapy in the literature and is substantially lower than other large studies involving hand therapy, which found that approximately 80% of patients have at least one postoperative therapy visit.<sup>15,16</sup> One potential cause of this discrepancy is the patient population in the database. The prior national studies included only commercially insured patients, while the current study included patients with Medicare and Medicaid. Although these patients have lower therapy utilization rates than those with commercial insurance, the commercially insured patients in the current study also had much lower utilization rates compared to the prior database studies, making this an unlikely explanation.

Another potential cause for this discrepancy is the extent of patient injury. In the current study, all concomitant injuries and procedures were manually reviewed and excluded, resulting in a cohort of patients with only FTR (with or without concomitant nerve injury/repair). The other studies excluded some hand injuries and procedures but did not exclude all concomitant injuries and procedures. This may have resulted in a study cohort with more injuries than in the current study. Patients with greater injuries likely have greater functional impairment and may be more likely to attend hand therapy. This explanation is supported by the findings of the current study, which demonstrate that patients with a greater number of tendons repaired are more likely to attend hand therapy postoperatively.

Finally, to avoid capturing patients visiting therapy for reasons other than rehabilitation for FTR, the current study assessed therapy

utilization by only looking at patients with an evaluation by a therapist postoperatively, while other studies include all procedure codes for physical or occupational therapy. This was investigated as a potential cause of the discrepancy, but including all the codes from prior studies increased the proportion of patients utilizing hand therapy by only a few percentage points.

While administrative data can be limited by coding inaccuracies, it is unlikely that there were errors in billable procedural codes accounting for a difference of 30 percentage points, as these codes are necessary for payments for therapists. We believe, therefore, that the hand therapy utilization rates are accurate for the current patient population despite being substantially lower than expected. The low rate of hand therapy utilization in the current study suggests that, although therapy attendance is high in some populations, others attend at much lower rates than expected. Thus, many patients are missing hand therapy that may improve their outcomes, and efforts should be made to improve utilization. Preoperatively, surgeons should ensure that they are prescribing hand therapy and are spending adequate time counseling patients on the importance of hand therapy for their recovery. Hand therapists may also play an important role in improving hand therapy attendance. Therapists should work closely with local hand surgeons and emphasize the importance of referrals for flexor tendon injuries. Therapists' offices can call patients who have been referred to them to confirm attendance and schedule an appointment, and when patients attend therapy, therapists should re-emphasize the importance of therapy for recovery after flexor tendon injury, explaining to patients the potential for stiffness and poor finger function. Such collaboration between surgeons and hand therapists can play an important role in improving hand therapy utilization, and anecdotally, the authors of the current study have found open communication between therapists and surgeons to improve the utilization of therapy and reduce the time to therapy initiation.

From 2010 to 2020, hand therapy utilization is shown to have significantly increased, which may represent an improvement in

**Table 1**  
Characteristics of patients with flexor tendon repair by postoperative hand therapy utilization

	Hand therapy	No hand therapy	<i>p</i> value
<i>N</i>	3319	3381	
Clinical characteristics			
Age—mean (SD)	44 (17)	44 (17)	0.161
18–24	532 (16%)	512 (15%)	
25–34	649 (20%)	689 (20%)	
35–44	572 (17%)	598 (18%)	
45–54	586 (18%)	541 (16%)	
55–64	564 (17%)	531 (16%)	
≥65	416 (13%)	511 (15%)	
Sex			<b>&lt; 0.001</b>
Female	1425 (43%)	1303 (39%)	
Male	1894 (57%)	2078 (61%)	
ECI score—mean (SD)	2 (3)	3 (3)	<b>0.015</b>
0–1	1479 (45%)	1604 (47%)	
2–3	940 (28%)	913 (27%)	
4–5	455 (14%)	465 (14%)	
≥6	445 (13%)	399 (12%)	
Number of tendon repairs			<b>&lt; 0.001</b>
1	1892 (57%)	2219 (66%)	
2	968 (29%)	859 (25%)	
3	253 (8%)	189 (6%)	
≥4	206 (6%)	38 (1%)	
Concomitant nerve procedure	1797 (54%)	1730 (51%)	<b>0.016</b>
Nonclinical characteristics			
Region			<b>&lt; 0.001</b>
Midwest	1029 (31%)	812 (24%)	
Northeast	820 (25%)	811 (24%)	
South	1035 (31%)	1206 (36%)	
West	416 (13%)	534 (16%)	
Insurance			<b>&lt; 0.001</b>
Commercial	2785 (84%)	2650 (78%)	
Medicaid	358 (11%)	370 (11%)	
Medicare	231 (7%)	341 (10%)	
Mean family income			<b>0.028</b>
Mean (SD)	\$77,635 (21,655)	\$76,387 (20,868)	
Median (IQR)	\$72,409 (22,271)	\$71,010 (22,184)	

ECI = Elixhauser Comorbidity Index; SD = standard deviation; IQR = interquartile range. *P*-values < 0.05 are considered statistically significant.

both patient and provider education regarding the resources for or beneficial impact of hand therapy. Patients with Medicaid experienced the greatest increase in hand therapy utilization over time. It is possible that changes in Medicaid policy have driven this effect, but there is no clear inflection point in the trend to suggest such a phenomenon.

The optimal timing of hand therapy remains an open question. Some providers worry about the risk of tendon rupture due to early initiation of hand therapy. That risk has not materialized in most studies, but Starr et al<sup>17</sup> report that early active motion may increase the risk of rupture to a greater degree than early passive motion.<sup>15,18</sup> Despite these reports, peak hand therapy utilization still occurs in postoperative weeks 4–5, whereas hand therapy utilization was only about 20% at week 1 and 35% at week 2. As delayed hand therapy can lead to a decreased range of motion, there remains further improvement to be made in the early initiation of hand therapy after FTR.<sup>9</sup>

A number of factors were found to be associated with a lack of hand therapy utilization. Patients who were men had a low comorbidity burden and fewer tendon repairs and were more likely to not receive postoperative hand therapy. It is possible that patients

**Table 2**  
Factors associated with lack of hand therapy utilization within 6 months of surgery

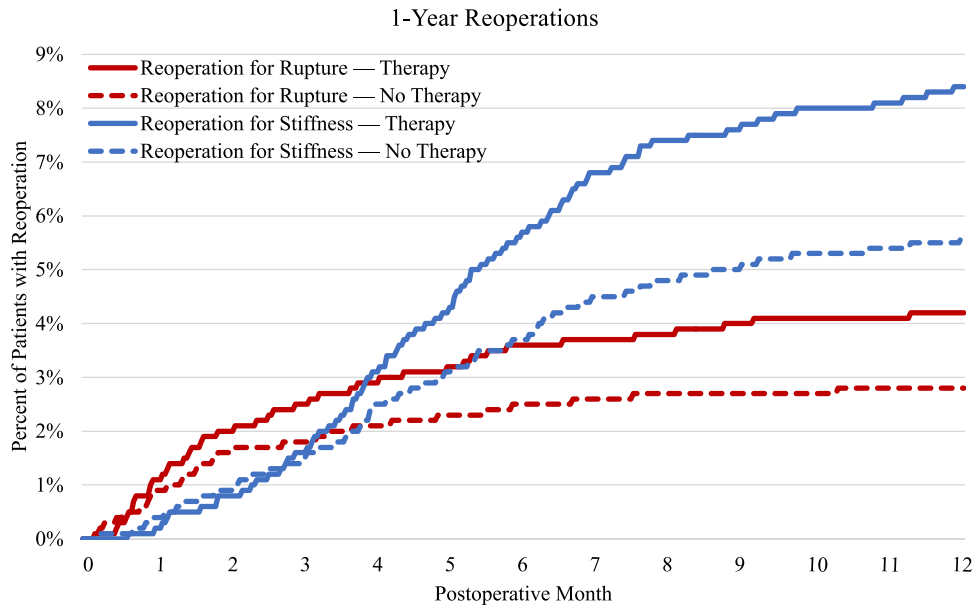
	OR (95% CI)	<i>p</i> value
Clinical characteristics		
Age (per 1-year increase)	1.00 (1.00, 1.00)	0.770
Male sex	1.20 (1.07, 1.33)	<b>0.001</b>
ECI score (per one-point decrease)	1.02 (1.00, 1.04)	<b>0.039</b>
Number of tendon repairs		
≥4 (reference)		
3	1.27 (0.92, 1.75)	0.151
2	1.54 (1.18, 2.03)	<b>0.002</b>
1	2.02 (1.56, 2.63)	<b>&lt; 0.001</b>
Concomitant nerve procedure	0.95 (0.86, 1.06)	0.4
Nonclinical characteristics		
Region		
Midwest (reference)		
Northeast	1.27 (1.07, 1.50)	<b>0.005</b>
South	1.48 (1.30, 1.69)	<b>&lt; 0.001</b>
West	1.69 (1.43, 2.00)	<b>&lt; 0.001</b>
Insurance		
Commercial (reference)		
Medicaid	1.11 (0.93, 1.32)	0.297
Medicare	1.65 (1.33, 2.06)	<b>&lt; 0.001</b>
Increasing mean family income (per \$10,000 increase)	0.97 (0.95, 1.00)	0.054

ECI = Elixhauser Comorbidity Index; OR = odds ratio; CI = confidence interval. *P*-values < 0.05 are considered statistically significant.

with fewer tendon repairs viewed their injury as less severe and, therefore, were less likely to use hand therapy. Similarly, there may be gender differences in how hand injuries are perceived, leading to differences in hand therapy utilization. Interestingly, this contrasts with the finding that men are less likely to no-show physical therapy appointments for musculoskeletal indications.<sup>19</sup> Patient familiarity with the health care system may also play a role—patients with a higher comorbidity burden are likely to have greater fluency with integrating frequent health care visits into their daily lives and may, therefore, be more amenable to incorporating hand therapy as part of their FTR recovery process.

Insurance coverage was found to be significantly associated with hand therapy utilization. Patients with Medicare were significantly more likely to lack hand therapy utilization. This is a finding not present in the literature. It may represent a disparity in access, as patients receiving Medicare are likely to be older and less mobile, a difference in patient willingness to attend hand therapy visits, or differing perceptions of the value of hand therapy. Notably, patients with Medicaid had no significant difference in hand therapy utilization compared with patients with commercial insurance. McLaughlin et al<sup>8</sup> have shown that Medicaid is a predictor both for no-showing a hand therapy appointment and decreased percentage of hand therapy appointments attended. In another retrospective cohort study, Bennett et al<sup>20</sup> found no effect of patient insurance on loss-to-follow-up for postoperative hand therapy. These results are conflicting and may warrant further investigation to continue improving access to and utilization of postoperative hand therapy.

Finally, patients with therapy utilization were at greater risk of undergoing a reoperation for tendon rupture and for stiffness, which mirrors the findings of a study by Lalchandani et al,<sup>16</sup> who noted that rates of reoperation increased with an increasing number of therapy visits. These results likely do not suggest that therapy itself increases the risk for complications following FTR. The more likely explanation is that patients who use therapy, especially those who attend many sessions, have postoperative problems such as finger stiffness. If these problems are persistent, they may lead to reoperation.



**Fig. 4.** Incidence of reoperations for rupture (red) and stiffness (blue) within 1 year of index flexor tendon repair. *Solid lines* indicate patients with postoperative hand therapy. *Dotted lines* indicate patients without postoperative hand therapy.

In addition to the limitations previously discussed, the current study was limited by its design as a retrospective database study. The results are reliant on accurate and reliable coding by a wide variety of providers of patient procedures, characteristics, and outcomes. Because of its retrospective nature, these results can suggest associations and potential pathways of the observed phenomena but are not able to determine causality. The current study is poorly equipped to comment on potentially relevant patient-level factors such as urbanicity, transportation, and socioeconomic status. Other important factors may be mistrust in the health care system or poor health care literacy. The current study is also unable to assess patient and provider attitudes regarding their procedures and the subsequent hand therapy regimen. Such information would provide greater insight into how the clinical and nonclinical predictors of hand therapy adherence identified in the study interact with the lived experience of the FTR patient. Future studies should be performed to investigate these patient- and provider-level factors.

In conclusion, the current retrospective database study of zone II FTRs shows that hand therapy utilization has increased through the 2010s, particularly for patients on Medicaid or commercial insurance, and that initiation of hand therapy in the early postoperative phase is still low in some populations. Surgeons and hand therapists should collaborate to increase therapy referrals and improve patient adherence to prescribed therapy.

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**Declaration of Competing Interest**

None.

**Appendix A**

CPT codes	
Procedure	Codes
Primary zone II flexor tendon repair	CPT-26356
Occupational therapy evaluation	CPT-97003, CPT-97004, CPT-97165, CPT-97166, CPT-97167, CPT-97168
Physical therapy evaluation	CPT-97001, CPT-97002, CPT-97161, CPT-97162, CPT-97163, CPT-97164
Therapeutic intervention by therapist	CPT-97110, CPT-97112, CPT-97140, CPT-97150, CPT-97530, CPT-97535, CPT-97533, CPT-97763, CPT-G0152, CPT-G8700, CPT-G8699, CPT-S9131, CPT-95852
Nerve procedure	CPT-64831, CPT-64832, CPT-64910, CPT-64702, CPT-64836, CPT-64890, CPT-64834, CPT-64835, CPT-64704, CPT-64837, CPT-64776, CPT-64911, CPT-64872, CPT-64901, CPT-64874, CPT-64895, CPT-64778, CPT-64876, CPT-64891, CPT-64896, CPT-64902
Reoperation for rupture	CPT-26357, CPT-26373, CPT-26352, CPT-26358, CPT-26390, CPT-26392, CPT-26485, CPT-26489
Reoperation for stiffness	CPT-26440, CPT-26442, CPT-26450, CPT-26455, CPT-26520, CPT-26525

CPT = Current Procedural Terminology.

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# JHT Read for Credit

## Quiz: # B62

**Record your answers on the Return Answer Form found on the tear-out coupon at the back of this issue. There is only one best answer for each question.**

- #1. The study design was
- RCTs
  - case study
  - retrospective cohort
  - prospective cohort
- #2. All patient subjects had flexor tendon repair in Zone
- II
  - I
  - III
  - IV
- #3. What percentage of the patients had no therapy evaluation
- 20
  - 30
  - 40
  - 50
- #4. The dependent variable was
- number of hand therapy visits
  - cost of hand therapy
  - reoperation
  - hand therapy utilization
- #5. The authors feel that hand therapy following FTR is underutilized
- false
  - true