EDITOR'S CHOICE

Comparison of Complication Risk Following Trigger Digit Release Performed in the Office Versus the Operating Room: A Population-Based Assessment

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Purpose Trigger digit release (TDR) performed in an office-based procedure room (PR) setting minimizes surgical costs compared with that performed in an operating room (OR); yet, it remains unclear whether the rates of major complications differ by setting. We hypothesized that surgical setting does not have an impact on the rate of major complications after TDR.

Methods Adult patients who underwent isolated TDR from 2006 to 2015 were identified from the MarketScan commercial database (IBM) using the provider current procedural terminology code 26055 with a concordant diagnosis on the same claim line (International Classification of Diseases, ninth revision, clinical modification 727.03). The PR cohort was defined by presence of a place-of-service code for an in-office procedure without OR or ambulatory center revenue codes, or anesthesiologist claims, on the day of the surgery. The OR cohort was defined by presence of an OR revenue code. We identified major medical complications, surgical site complications, as well as iatrogenic neurovascular and tendon complications within 90 days of the surgery using International Classification of Diseases, ninth revision, clinical modification diagnosis and/or current procedural terminology codes. Multivariable logistic regression was used to compare the risk of complications between the PR and OR groups while controlling for Elixhauser comorbidities, smoking, and demographics.

Results For 7,640 PR and 29,962 OR cases, the pooled rate of major medical complications was 0.99% (76/7,640) and 1.47% (440/29,962), respectively. The PR setting was associated with a significantly lower risk of major medical complications in the multivariable analysis (adjusted odds ratio 0.76; 95% confidence interval 0.60−0.98). The pooled rate of surgical site complications was 0.67% (51/7,640) and 0.88% (265/29,962) for the PR and OR cases, respectively, with no difference between the surgical settings in the multivariable analysis (adjusted odds ratio 0.81; 95% confidence interval 0.60−1.10). Iatrogenic complications were infrequently observed (PR 5/7,640 [0.07%]; OR 26/29,962 [0.09%]).

Conclusions Compared with performing TDR in the OR using a spectrum of commonly used anesthesia types, performing TDR in the PR using local-only anesthesia was associated with a comparably low risk of major medical complications, surgical complications, and iatrogenic complications. *(J Hand Surg Am. 2021;46(10):877−887.*

Type of study/level of evidence Prognostic II.

Key words Complications, MarketScan database, trigger digit/finger release, wide-awake local anesthesia no tourniquet (WALANT) hand surgery.

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The value of care has been described as the treatment outcome or level of improvement per unit cost.[1–4] Policies that allow for value-based payment models have recently led to an increased focus on efforts to improve the value of health care delivery in the United States.[5] In the field of surgery, the value of care may be increased by improving clinical or functional outcomes in a way that does not disproportionately increase treatment costs or reducing surgical costs while maintaining comparable clinical, functional, and safety outcomes.

In the field of hand surgery, a substantial body of literature has recently been amassed suggesting that performing minor surgeries in a procedure room (PR) setting substantially reduces direct costs compared with those performed in an operating room (OR) setting. Specifically, performing surgeries such as trigger digit release (TDR), carpal tunnel release, or other minor procedures that are amenable to wide-awake local anesthesia, no tourniquet techniques in the PR setting appear to improve the value of care for patients in the United States civilian and military populations, Canada, and the United Kingdom.[6–13] The use of the PR setting may also lead to reduced costs by decreasing the use of preoperative medical consultation and testing.[7]

Less is known about the PR safety profile and how it compares with the OR safety profile. Specifically, potential differences in procedural sterility, the lack of access to advanced medical services in case of an emergency in the PR setting, the omission of an anesthesiologist and associated intraoperative monitoring, or the potential for incomplete local anesthesia to contribute to iatrogenic injuries may be concerns for some surgeons. Information pertaining to complications is important when balancing the value equation because the cost-saving potential of the PR setting could theoretically be offset if the rates of rare but major complications are higher. Several published reports have documented a low rate of complications following a variety of hand surgeries performed in the PR setting.[9,10,14–16] Two studies comparing the complication rates between the PR and OR settings reported low complication rates for patients treated with TDR in the PR setting.[11,17] However, these findings were limited by small samples because both enrolled less than 100 patients. In a larger, noncomparative series that specifically evaluated infection rates in 1,504 consecutive patients undergoing carpal tunnel release in the PR setting, low rates of superficial and deep infections were observed (0.4% and 0%, respectively).[18] However, medical and iatrogenic complications related to neurovascular or tendon structures were not evaluated. We were unable to identify a large, appropriately powered study that compared the rates of medical, wound, or iatrogenic surgical complications after minor hand surgeries between the PR and OR settings.

Therefore, our aim was to evaluate the null hypothesis that the risk of major medical complications does not differ between the PR and OR surgical settings in a large, geographically diverse population of privately insured individuals undergoing TDR. Our secondary null hypotheses were that the rates of surgical site complications and rates of iatrogenic complications, such as a neurovascular or tendon injury, do not differ between the PR and OR surgical settings following TDR. Our tertiary null hypothesis was that the rate of postoperative admission does not differ between the surgical settings.

METHODS

Definition of PR and OR TDR surgery populations

From the MarketScan commercial database (IBM), we identified adults aged 18–64 years who underwent TDR surgery from 7/1/2006 to 6/30/2015. The MarketScan database includes medical and outpatient pharmacy claims and enrollment information contributed by employers and commercial health insurance plans for over 150 million persons during the timeframe of the study. Data for employees, dependents, and persons with Consolidated Omnibus Budget Reconciliation Act continuation covered by employer-sponsored and other commercial health insurance plans are included in the database. Persons with other types of private insurance, worker compensation, and government-sponsored plans as well as uninsured persons are not included in the database. The MarketScan database is a deidentified limited dataset; thus, this study was reviewed and considered exempt by the University of Utah institutional review board and the Washington University human research protection office.

Persons undergoing isolated TDR were identified from the inpatient and outpatient medical claims based on the current procedural terminology-4 code 26055 for TDR coded by a provider. Eligible procedures were required to have a diagnosis of trigger finger (International Classification of Diseases, ninth revision, clinical modification 727.03) on the claim line for the procedure. We required medical insurance coverage at least 180 days before the surgery through

90 days after the surgery to assess comorbidities and complications. To determine the performance site of the procedure, uniform billing codes were used to identify procedures performed in the OR based on the revenue center code for major OR services (0360 and 0361). Procedures performed in the PR setting were identified using a place-of-service code of 11 (in-office procedure) on the surgeon claim line, with no OR revenue center code for OR or ambulatory surgery services (0360, 0361, or 0490) and no claim for general, regional, sedation, or nerve block anesthesia on the day of the surgery.

Trigger digit release procedures among persons who underwent additional simultaneous surgical procedures on the date of the TDR were excluded to compare the outcomes of isolated TDR depending on the performance site of the procedure. Unrelated procedures included a wide range of current procedural terminology-4 codes (10021−69990), except those for OR procedures for nerve block (64415−64417 and 64450) or an iatrogenic-related procedure (suture of a major peripheral nerve [64856 and 64857], repair of a blood vessel [35206 and 35207], ligation of an extremity artery [37618], and repair/advancement of a flexor tendon [26350 and 26356]). Procedures that were potentially related to addressing iatrogenic injuries (Appendix E1, available online on the *Journal's* website at www.jhandsurg.org) were allowed on the TDR date to avoid excluding individuals with intraoperative complications treated during the index TDR surgery. Patients undergoing other additional simultaneous procedures were excluded.

Procedures in persons that were coded for non-iatrogenic injuries (eg, injury, open wound, or rupture to the vessels/nerves/tendons associated with TDR; Appendix E2, available online on the *Journal's* website at www.jhandsurg.org) in the 30 days before the surgery were excluded. Procedures performed on the day of an emergency department visit or after the date of admission during hospitalization for TDR surgery were excluded to reduce the possibility of erroneously including patients treated surgically for suppurative flexor tenosynovitis. For those who underwent >1 TDR procedure during the study period, only the first procedure meeting the eligibility criteria was included. This was done to avoid a potential bias that could have resulted from analyzing the same patient (with presumably the same comorbidity burden) multiple times. A summary of all the exclusions is provided in Appendix E3 (available online on the *Journal's* website at www.jhandsurg.org).

Identification of underlying comorbidities and other potential risk factors for complications

Comorbidities were identified using the Elixhauser comorbidity index, requiring facility coding in ≥1 inpatient hospitalization and/or ≥2 provider/outpatient claims spaced at least 30 days apart, with the exception of obesity, weight loss, drug abuse, alcohol abuse, and tobacco use, all of which only required a single claim.[19−21]

Identification of major medical and surgical outcomes

A major medical complication within 90 days of the surgical date was the primary study outcome, defined as International Classification of Diseases, ninth revision, clinical modification diagnosis/procedure codes for any of the following: acute myocardial infarction, acute stroke, transient ischemic attack, death, cardiac/respiratory arrest, respiratory failure, acute pulmonary embolism, acute deep vein thrombosis, congestive heart failure exacerbation, acute renal failure, and postoperative shock (Appendix E4, available online on the *Journal's* website at www.jhandsurg.org). Because the complications were acute events, only a single code was required within 90 days after the TDR.

Surgical site complications within 90 days after the surgery were defined using International Classification of Diseases, ninth revision, clinical modification codes for surgical site infection, wound disruption, seroma, hematoma, hemorrhage complicating a procedure, and nonhealing wound (Appendix E5, available online on the *Journal's* website at www.jhandsurg.org). Iatrogenic complications occurring during the index surgery were defined as new injuries to neurovascular and tendon structures that were not coded in the 6 months prior to the TDR date but were diagnosed or surgically treated within 90 days of the index surgery date (Appendix E6, available online on the *Journal's* website at www.jhandsurg.org). Patients with an inpatient hospitalization (all-cause) within 90 days of the index surgery date were also identified using inpatient services files.

Statistical methods

Complication rates and demographics were compared between PR and OR groups using the chi-square or Fisher exact test for binary variables and Student *t* test or Mann-Whitney U test for continuous variables. Multivariable logistic regression was performed to identify factors associated with medical, surgical, and iatrogenic complications, with surgery performance location as the primary exposure forced in the model.

TABLE 1. Summary of Demographic Data for PR and OR Groups

Variable	PR (n = 7,640)	OR (n = 29,962)	*P* Value
Age (y)			
18–39	255 (3.34%)	1,206 (4.03%)	**<.05**
40–49	1,060 (13.87%)	4,667 (15.58%)	-
50–59	4,036 (52.83%)	16,212 (54.11%)	-
60–64	2,289 (29.96%)	7,877 (26.29%)	-
Anesthesia type			
General or regional	0 (0.00%)	21,927 (73.18%)	N/A
Sedation	0 (0.00%)	30 (0.10%)	-
Local	7,640 (100.00%)	8,005 (26.72%)	-
Postoperative nerve block	0 (0.00%)	717 (2.39%)	-
Insurance type			
HMO or POS with capitation	1,537 (20.12%)	3,747 (12.51%)	**<.05**
All other plan types	6,103 (79.88%)	26,215 (87.49%)	-
Region			
Northeast	941 (12.32%)	5,223 (17.43%)	**<.05**
North Central	1,918 (25.10%)	9,972 (33.28%)	-
South	2,287 (29.93%)	11,111 (37.08%)	-
West	2,494 (32.64%)	3,656 (12.20%)	-
Residence type			
Urban	6,381 (83.52%)	23,113 (77.14%)	**<.05**
Rural	1,259 (16.48%)	6,849 (22.86%)	-
Sex			
Male	2,711 (35.48%)	9,912 (33.08%)	**<.05**
Female	4,929 (64.52%)	20,050 (66.92%)	-

HMO, Health Maintenance Organization; N/A, not applicable; POS, point of service.
Binned continuous variables and categorical variables were analyzed using the chi-square test. The bolded *P* values are statistically significant. The "Local" group of anesthesia type was defined as the lack of general, regional, sedation, and postoperative nerve block coding. Values may add up to >100% because anesthesia type and postoperative block are not mutually exclusive.

Variables with $P < .10$ in bivariate analyses were initially included in the full models. Variables were removed from the model in a backward stepwise manner, with $P < .05$ as the threshold for retention. The multivariable models included the following predictor variables: surgical setting, Elixhauser comorbidity index, smoking status, and all demographic factors in Table 1. The potential multicollinearity of independent variables was assessed using variance inflation factors.

A *post hoc* power calculation was performed using the observed ratio of the number of PR and OR cases (7,640 PR and 29,962 OR cases, or 1:3.92). To achieve a power of 80% with $\alpha = 0.05$, a total of 5,458 PR and 26,853 OR cases were needed to have a detected difference of 0.40% for major medical complications (0.60% vs 1.00%) using a 2-tailed 2-proportion test. *P* values <.05 were considered statistically significant.

RESULTS

After applying the exclusion criteria (Appendix E3), 37,602 patients were included in the analysis: 7,640 were treated with isolated TDR in the PR and 29,962 in the OR. The mean age of the included patients was 54 ± 7 years, and 66.4% (24,979/37,602) were women. Additional demographic factors are provided in Table 1. The comorbidities and smoking status, with comparisons between the PR and OR cohorts, are shown in Table 2.

Major medical outcomes

The crude pooled rate of major medical complication within 90 days after the surgery was 0.99% (76/

TABLE 2. Summary of Comorbidity Data for PR and OR Groups

Variable	PR (n = 7,640)	OR (n = 29,962)	*P* Value
Elixhauser comorbidities			
AIDS	7 (0.09%)	21 (0.07%)	.538
Alcohol abuse	24 (0.31%)	102 (0.34%)	.723
Deficiency anemia	65 (0.85%)	314 (1.05%)	.123
Rheumatoid arthritis/collagen vascular disease	90 (1.18%)	382 (1.27%)	.497
Chronic blood loss anemia	4 (0.05%)	7 (0.02%)	.250
Congestive heart failure	8 (0.10%)	101 (0.34%)	**<.05**
Chronic pulmonary disease	121 (1.58%)	964 (3.22%)	**<.05**
Chronic kidney disease	36 (0.47%)	191 (0.64%)	.094
Coagulopathy	4 (0.05%)	43 (0.14%)	**<.05**
Depression	130 (1.70%)	697 (2.33%)	**<.05**
Diabetes (uncomplicated or complicated)	956 (12.51%)	5,123 (17.10%)	**<.05**
Drug abuse	24 (0.31%)	117 (0.39%)	.329
Hypertension (uncomplicated or complicated)	742 (9.71%)	5,404 (18.04%)	**<.05**
Hypothyroidism	142 (1.86%)	1,003 (3.35%)	**<.05**
Liver disease	30 (0.39%)	109 (0.36%)	.710
Lymphoma	11 (0.14%)	54 (0.18%)	.496
Fluid and electrolyte disorders	29 (0.38%)	153 (0.51%)	.141
Metastatic cancer	6 (0.08%)	21 (0.07%)	.806
Neurological disorders	52 (0.68%)	242 (0.81%)	.260
Obesity	322 (4.21%)	2,324 (7.76%)	**<.05**
Paralysis	7 (0.09%)	18 (0.06%)	.339
Peripheral vascular disease	11 (0.14%)	92 (0.31%)	**<.05**
Psychoses	177 (2.32%)	750 (2.50%)	.348
Pulmonary circulation disease	4 (0.05%)	34 (0.11%)	.159
Solid tumor without metastasis	126 (1.65%)	500 (1.67%)	.905
Valvular disease	25 (0.33%)	123 (0.41%)	.299
Weight loss	23 (0.30%)	108 (0.36%)	.432
Smoking (yes vs no)	199 (2.60%)	2,953 (9.86%)	**<.05**

AIDS, acquired immunodeficiency virus.
Categorical variables were analyzed using the chi-square or Fisher exact test (where appropriate). The bolded *P* values are statistically significant.

7,640) for the PR group and 1.47% (440/29,962) for the OR group ($P < .05$). Table 3 illustrates the rate of each medical complication for both the surgical settings. The multivariable analysis demonstrated that the risk of major medical complications was significantly lower in the PR setting than in the OR setting (adjusted odds ratio 0.76; 95% confidence interval 0.60−0.98; $P < .05$). Anemia, chronic pulmonary disease, diabetes, hypertension, psychological disorders/psychoses, and older age were associated with a significantly increased risk of a major medical complication within 90 days after the surgery in the multivariable model (Table 4).

Surgical site and iatrogenic injury outcomes

The crude pooled rate of surgical site complications was 0.67% (51/7,640) for the PR group and 0.88% (265/29,962) for the OR group ($P = .064$). Table 5 illustrates the rates of individual surgical site complications for both the surgical settings. There was no association between surgical setting and the risk of surgical site complications in the multivariable analysis (adjusted odds ratio 0.81; 95% confidence interval 0.60−1.10; $P = .170$). Diabetes, older age, and rural residence (vs urban) were associated with a significantly increased risk of surgical site complications (Table 6). In other words, the elevated risk of

TABLE 3. Unadjusted 90-Day Rates of Major Medical Complications

Complication Type	PR (n = 7,640)	OR (n = 29,962)	*P* Value
Pooled major medical complications	76 (0.99%)	440 (1.47%)	**<.05**
Acute MI	6 (0.08%)	22 (0.07%)	.883
Acute stroke	40 (0.52%)	207 (0.69%)	.106
TIA	5 (0.07%)	58 (0.19%)	**<.05**
Death	1 (0.01%)	2 (0.01%)	.494
Cardiac/respiratory arrest	0 (0.00%)	6 (0.02%)	.608
Respiratory failure	4 (0.05%)	25 (0.08%)	.493
Acute PE	9 (0.12%)	43 (0.14%)	.589
Acute DVT	12 (0.16%)	67 (0.22%)	.257
Congestive heart failure exacerbation	2 (0.03%)	11 (0.04%)	1.000
Acute renal failure	8 (0.10%)	59 (0.20%)	.088
Postoperative shock	0 (0.00%)	0 (0.00%)	N/A

DVT, deep vein thrombosis; MI, myocardial infarction; N/A, not applicable; PE, pulmonary embolism; TIA, transient ischemic attack.
Categorical variables were analyzed using the chi-square or Fisher exact test (where appropriate). The bolded *P* values are statistically significant.

surgical site infections observed for patients with diabetes and older age as well as for those in rural residences was independent of the surgical setting, and therefore, this finding applied to both the PR and OR settings.

The crude pooled rate of iatrogenic surgical complications was 0.07% (5/7,640) for the PR group and 0.09% (26/29,962) for the OR group ($P = .562$, chi-square test; Table 5). The low number of iatrogenic surgical complications precluded multivariable modeling.

Ninety-day postoperative admission outcomes

A univariate analysis demonstrated a significantly lower rate of all-cause 90-day postoperative admission following TDR performed in the PR compared with that following TDR performed in the OR (1.61% [123/7,640] vs 2.31% [693/29,962], respectively; $P < .05$). Table E1 (available online on the *Journal's* website at www.jhandsurg.org) shows that the PR setting was associated with a 22% reduction in the risk of hospitalization, which was detected using a multivariable model controlling for demographic factors and comorbidities (adjusted odds ratio 0.78; 95% confidence interval 0.64−0.95; $P < .05$).

The largest variance inflation factor across the 3 multivariable regression models was 1.08, which was well below previously described thresholds of 5−10; therefore, there was no evidence of important multicollinearity.[22−24]

DISCUSSION

The primary finding of our study was that TDR performed in the office-based PR setting was associated with a small, but significant, reduction in the risk of major medical complications compared with that performed in the traditional OR setting. Specifically, we observed that 0.99% of the patients treated in the PR and 1.47% of the patients treated in the OR experienced a major medical complication within 90 days of the surgery.

Although we were unable to identify a large comparative study comparing the complication rates for common hand surgeries between the PR and OR settings, our results agree with the existing literature. The risk of experiencing a major intraoperative medical or surgical complication demonstrated in our study is similar to the findings published by Lipira et al.[25] They demonstrated the risk of myocardial infarction and pulmonary embolism each to be <0.1% using the National Surgical Quality Improvement Program database, which is similar to our findings. Additional studies have also demonstrated low rates of major intraoperative complications for elective hand surgery performed in the PR or clinical setting.[11,26] Although differences between these surgical settings were not evaluated, Lalchandani et al,[27] using the PearlDiver database (PearlDiver Inc.), found a lower rate of medical and surgical complications among patients receiving local-only anesthesia for a variety of minor hand surgeries than among patients receiving sedation,

TABLE 4. Multivariable Logistic Regression Model for Pooled Major Medical Complications

Variable*	Odds Ratio	95% Wald Confidence Limits		*P* Value
		Lower Limit	Upper Limit	
Surgical setting (PR reference group [vs OR])	0.76	0.60	0.98	**<.05**
Elixhauser comorbidity index variables†	-	-	-	-
Anemia	2.94	1.91	4.54	**<.05**
Chronic pulmonary disease	2.96	2.20	3.98	**<.05**
Diabetes	1.91	1.57	2.33	**<.05**
Hypertension	1.80	1.48	2.20	**<.05**
Psychological disorders/psychosis	1.96	1.33	2.89	**<.05**
Age category (vs 40–49 years) (y)	-	-	-	-
18–39	0.45	0.19	1.06	.066
50–59	1.35	1.00	1.83	**<.05**
60–64	2.02	1.49	2.75	**<.05**

The bolded *P* values are statistically significant.

*The following additional variables were included in the model but were eliminated through a backward term-selection method: depression, hypothyroidism, obesity, region, and smoking.

†The following Elixhauser comorbidity index variables were not analyzed in this model because of insignificance in the univariate analysis ($P > .10$): insurance type, residence type (rural vs urban), rheumatoid arthritis, and solid tumor without metastasis. The following variables were not analyzed in this model because of counts <5: AIDS, alcohol abuse, chronic blood loss anemia, chronic kidney disease, congestive heart failure, coagulopathy, drug abuse, fluid and electrolyte disorders, liver disease, lymphoma, metastatic cancer, neurological disorders, paralysis, peripheral vascular disease, pulmonary circulation disease, valvular disease, and weight loss.

TABLE 5. Unadjusted Rates of 90-Day Surgical Site and Iatrogenic Surgical Complications

Complication Type	PR (n = 7,640)	OR (n = 29,962)	*P* Value
Pooled surgical site complications	51 (0.67%)	265 (0.88%)	**.064**
Surgical site infection	40 (0.52%)	178 (0.59%)	.469
Surgical site wound disruption	4 (0.05%)	63 (0.21%)	.002
Surgical site seroma	2 (0.03%)	10 (0.03%)	1.000
Surgical site hematoma	2 (0.03%)	9 (0.03%)	1.000
Surgical site nonhealing wound	6 (0.08%)	30 (0.10%)	.586
Hemorrhage complicating a procedure	1 (0.01%)	8 (0.03%)	.697
Pooled iatrogenic complications	5 (0.07%)	26 (0.09%)	**.562**
New nerve injury	4 (0.05%)	14 (0.05%)	.773
New blood vessel injury	0 (0.00%)	2 (0.01%)	1.000
New tendon injury	2 (0.03%)	9 (0.03%)	1.000
Iatrogenic injury	2 (0.03%)	10 (0.03%)	1.000

Categorical variables were analyzed using the chi-square or Fisher exact test (where appropriate). The bolded *P* values are statistically significant.

regional, or general anesthesia. The results of the current study add to the findings of Lalchandani et al.[27] Taken a step further, we observed that performing TDR under local-only anesthesia in the absence of an anesthesiologist or associated monitoring demonstrated a safety profile similar to that of a TDR performed in the OR setting.

Another important finding of our study was that a similar risk of postoperative wound complications was observed for TDR performed in the PR and OR settings. Specifically, our study demonstrated a surgical site infection rate of 0.52% for the PR group and 0.59% for the OR group. This finding is consistent with those of several previous studies evaluating the

TABLE 6. Multivariable Logistic Regression Model for Pooled Surgical Site Complications

Variable*	Odds Ratio	95% Wald Confidence Limits		*P* Value
		Lower Limit	Upper Limit	
Surgical setting (PR reference group [vs OR])	0.81	0.60	1.10	.170
Elixhauser comorbidity index variables†	-	-	-	-
Diabetes	1.63	1.26	2.12	**<.05**
Residence type (rural vs urban)	1.49	1.16	1.90	**<.05**
Age category (vs 40−49 years) (y)				
18−39	1.43	0.87	2.34	.155
50−59	0.83	0.61	1.11	.205
60−64	0.61	0.43	0.87	**<.05**

The bolded *P* values are statistically significant.

*The following additional variables were included in the model but eliminated through a backward term-selection method: chronic lung disease, hypertension, hypothyroidism, and obesity.

†The following Elixhauser comorbidity index variables were not analyzed in this model because of insignificance in the univariate analysis ($P > .10$): depression, insurance type, psychoses, solid tumor without metastasis, region, and sex. The following variables were not included in the final model because of counts <5: AIDS, alcohol abuse, chronic blood loss anemia, chronic kidney disease, congestive heart failure, coagulopathy, deficiency anemia, drug abuse, fluid and electrolyte disorders, liver disease, lymphoma, metastatic cancer, neurological disorders, paralysis, peripheral vascular disease, pulmonary circulation disease, valvular disease, and weight loss.

infection rate after elective hand surgery in diverse populations, including a Canadian multicenter cohort, a Veterans Association population, a Medicare population, and 2 separate United States single-center cohorts.[18,25,26,28−30] Tosti et al[29] demonstrated an infection rate of 0.66% after 600 consecutive elective soft-tissue hand surgeries in a multicenter, non-database cohort, and Lipira et al[25] demonstrated a surgical site infection rate of 1.1% among an assortment of 208 different hand-specific current procedural terminology codes. Additionally, Lipira et al[25] reported a wound dehiscence rate of 0.2%, which is similar to our finding of 0.21% in the OR setting. Our findings are also similar to the infection rate of 0.32% reported by Werner et al[28] in their study of 454,987 carpal tunnel releases performed in a Medicare population. We believe that our findings add to the literature because the current study used a different database (MarketScan database) and was comparative with meaningful power to detect differences in these rare complications.

Our study also found a similarly low rate of iatrogenic complications in both the surgical settings. Specifically, the rate of nerve injury was 0.05% for the PR and OR settings. This finding is consistent with the results demonstrated by Lipira et al,[25] who reported a nerve injury rate of <0.1%.

Additional study findings include a significantly lower risk of all-cause 90-day postoperative admission following TDR performed in the PR versus that performed in the OR. Although this finding was independent of comorbidities and demographic factors, it was limited because we were unable to attribute the exact cause to the surgery setting itself (as opposed to anesthesia-specific complications or those related to a greater comorbidity burden among the patients treated in the OR). Therefore, it is unclear whether this observation is an association, and we cannot assume its causation. Although prior literature was limited for comparison, our estimated rates of admission (PR 1.61%, OR 2.31%) were subjectively similar to, but slightly higher than, previously reported rates. Goodman et al[32] reported a 0.12% rate of unplanned reoperation and/or admission following TDR performed by 2 surgeons, and Menendez and Ring[31]reported a 3% rate of postoperative presentation to the emergency department within 30 days of surgery, although the rate of admission was not evaluated.[32] Although most patients seeking emergent or urgent care following hand surgeries do so within the first 2 weeks of the surgery, it is possible that our focus on 90 days postoperatively, versus a 30-day postoperative window (as in the 2 cited studies), may have contributed to our higher rate.

There are several limitations to this study. Given that our study was conducted using an administrative database, it was susceptible to possible coding errors. Additionally, the MarketScan database applies specifically to commercially insured patients less than 65 years of age, which may have affected the ability to generalize the findings to older (Medicare) or more resource-limited (Medicaid or uninsured) patient populations. Propensity score matching has become an increasingly popular method for

analyzing nonrandomized observational data to emulate some of the advantages of a randomized trial.[33,34] We did not perform this type of analysis because it was unclear whether the patients included for the surgery had an equal opportunity for treatment in the PR and OR, which is a prerequisite for such modeling. It is possible that the implementation of propensity score matching methods would have resulted in a different observation. We acknowledge that there is a potential for a selection bias, wherein patients treated in the PR were observed to have a lower medical comorbidity burden than patients treated in the OR in general. Specifically, there were significant differences in the prevalence of congestive heart failure, pulmonary disease, coagulopathy, depression, diabetes, hypertension, hypothyroidism, obesity, peripheral vascular disease, and smoking. Although we controlled for a multitude of medical comorbidities, the extent to which our findings reflect differences in the underlying patient populations between the surgical settings versus differences in complications directly due to surgical setting alone is unclear. In other words, despite our attempts to minimize selection bias, we cannot assume that it was completely eliminated. A residual bias due to several sources is possible: underdetection of certain comorbidities because of limitations in coding; inability to control for unmeasured confounders; and lack of indicators of disease severity even for measured variables (eg, heart failure classification or the amount of smoking). There is no measure of severity of the disease in claims data. Despite this limitation, our results reflect the adjusted odds ratios of the complication risk; that is, they represent the independent effect of PR versus OR after adjusting for other variables in the model.

We were also limited in our ability to determine the number of TDRs performed in a single operation. The effect of performing multiple simultaneous TDRs on complication rates is unclear. Although the low rates of iatrogenic tendon and neurovascular injuries were likely to be clinically relevant because of the substantial associated morbidity, these rates were too low to perform a multivariable analysis to control for comorbidities and demographics, which did differ between the PR and OR groups. Although it is possible that different surgeons experience different complication rates, we were unable to study differences in the complication rates at the provider level or account for the clustering of patients within providers. Nearly half of the potential TDR cohort was excluded because of the lack of coding that allowed for the determination of the site of surgery (PR vs OR); this might have been a potential source of bias if the excluded patients differed from the included patients. It is possible that comorbidities were more accurately documented for patients treated in the OR than for patients treated in the PR, the latter of which were unlikely to be evaluated by an anesthesiologist. Such a bias would further favor the PR over the OR, and this is a potential limitation of our analysis of complications. Although it is possible that the complication rates differed between main OR and ambulatory OR settings or between local-only surgeries in the OR and local-only surgeries in the PR, we did not address these questions because of the concerns that statistical power would not have been adequate for these subanalyses and differentiating between the 2 settings may have been unreliable using claims data. Nonetheless, prior findings of Hustedt et al[35] support this because they found, using the National Surgical Quality Improvement Program database, a higher complication risk with general anesthesia, as opposed to that with local-only anesthesia, within a cohort of patients undergoing a variety of hand surgeries. They also found a greater risk of complications among patients over 65 years of age who received sedation compared with those who received local-only anesthesia.[35] Minor complications, such as postoperative nausea and vomiting, were not studied because our focus was on major complications, and we anticipated that these were likely undercoded in the claims data, given that they are not associated with reimbursement. Our study is limited in the ability to comment on the relative impact of the surgical setting versus anesthesia type on the observed differences between the PR and OR because the PR setting and local-only anesthesia are 2 variables that are linked. Further, the results of the current study do not address the reasons for the observed differences in the admission rates between the patients treated in the PR and OR. It is unclear whether these differences are related to surgical setting, anesthesia-related complications, the finding that specific comorbidities are significantly more common among patients treated in the OR (which might have led to unrelated admissions), or a combination of factors. As such, our ability to interpret these data is limited, although we speculate that anesthesia-related complications and those related to a higher comorbidity burden for patients treated in the OR are responsible rather than the surgery setting itself.

Our results are informative, considering the emphasis on value in health care. Maliha et al[11] and

Kazmers et al[10] have demonstrated that TDR performed in the PR is substantially less costly than the same procedure performed in the OR. Rabinowitz et al[17] found that patients treated with TDR in the PR reported greater satisfaction and functional outcomes than those treated in the OR. Synthesizing these prior studies and the results of the current study, it appears that TDR performed in a PR is less expensive, similarly safe, and leads to similar functional outcomes compared with TDR performed in the OR.

The risk of major medical complications, all-cause 90-day postoperative inpatient admission rates, risk of wound complications, and risk of iatrogenic surgical complications were similar between the surgical settings. In this regard, TDR performed in a PR under local-only anesthesia appears to be equally safe as TDR performed in an OR using a spectrum of commonly used anesthesia types.

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Appendix E1. Coding Used to Identify and Exclude Iatrogenic Injuries

Current procedural terminology codes in the range of 10021−69990 were reviewed. The following codes for iatrogenic injuries and nerve block were excluded:

Iatrogenic injuries: 64856, 64857, 35206, 35207, 37618, 26356, 26350

Nerve block: 64415, 64416, 64417, 64450

Appendix E2. Coding Used to Identify and Exclude Noniatrogenic Injuries

1. Injury median nerve: 955.1
2. Injury ulnar nerve: 955.2
3. Injury radial nerve: 955.3
4. Injury radial vessels: 903.2
5. Injury ulnar vessels: 903.3
6. Compartment syndrome: 958.8
7. Rupture of the hand/wrist extensor tendon: 727.63
8. Rupture of the hand/wrist flexor tendons: 727.64
9. Late effect of tendon injury (nonspecific): 905.8
10. Injury to nerve, cutaneous sensory, and upper limb: 955.5
11. Injury to nerve, shoulder girdle/arm/forearm/hand-wrist/finger: 955.9
12. Injury to nerve, brachial plexus: 953.4
13. Injury to nerve, finger: 955.6
14. Injury to nerve, peripheral, multiple in several locations: 957.8
15. Injury to nerve, cervical plexus: 953.0
16. Open wound of the elbow/forearm: 881.0x, 881.1x, 881.2x
17. Open wound of the hand: 882.0, 882.1, 882.2
18. Open wound of the fingers: 883.0, 883.1, 883.2

Appendix E3. Summary of Study Exclusions

There were 174,229 trigger digit release (TDR) procedures between 7/1/2006 and 6/30/2015 in persons aged 18−64 years residing in the United States. The following procedures were excluded from study participation:

1. Dropped 35,384 procedures because of lack of health insurance coverage in the 180 days prior to and/or 90 days after the surgery.
2. Dropped 1,009 procedures because of diagnosis codes for noniatrogenic injuries in the 30 days prior to or on the date of TDR (Appendix E1).
3. Dropped 1,518 procedures because of current procedural terminology codes for other simultaneous wrist/hand surgeries in the 180 days prior to or on the TDR date.
4. Dropped 39,708 procedures because of another surgical/procedure current procedural terminology code on the TDR date.
5. Dropped 1,149 procedures because of evidence of an emergency department visit on the TDR date.
6. Dropped 6 procedures because of surgery after the date of admission during an inpatient hospitalization.
7. Dropped 54,052 procedures when the performance of the procedure in the operating room or procedure room could not be determined.
8. Dropped 3,801 procedures when limiting inclusion to the first eligible TDR per patient.
9. There were 37,602 TDR procedures in the final dataset.

Appendix E4. Coding Used to Identify Major Medical Complications

Acute myocardial infarction

410.01, 410.11, 410.21, 410.31, 410.41, 410.51, 410.61, 410.71, 410.81, 410.91

Acute stroke

1. Subarachnoid: 430
2. Intracerebral hemorrhage: 431
3. Other: 432.0 (nontraumatic extradural), 432.1 (subdural), 432.9 (unspecified ICH)
4. Occlusion of precerebral arteries: 433.00/.01/.10/.11/.20/.21/.30/.31/.80/.81/.90/.91
5. Occlusion of cerebral arteries: 434.00/.01/.10/.11/.90/.91
6. Acute but ill defined: 436

Transient ischemic attack

435.0/.1/.2/.3/.8/.9

Death

798.1/.2/.9 (discharge status was also used to identify death)

Cardiac/respiratory arrest

1. Cardiac arrest: 427.5
2. Respiratory arrest: 799.1
3. Due to a procedure: 977.1

Respiratory failure

1. Failure: 518.81
2. Failure secondary to surgery: 518.51

3. Acute on chronic: 518.84
4. International Classification of Diseases, ninth revision, procedure code: 96.72

Acute pulmonary embolism

Pulmonary embolism: 415.11/.13/.19

Acute deep vein thrombosis

1. Acute lower extremity deep vein thrombosis: 453.40/.41/.42
2. Acute deep vein thrombosis of other veins: 453.81-89

Congestive heart failure exacerbation

428.21, 428.23, 428.31, 428.33, 428.41, 428.43

Acute renal failure

584.5, 584.6, 584.7, 584.8, 584.9

Postoperative shock

998.0, 998.01, 998.02, 998.09

Appendix E5. Coding Used to Identify Surgical Wound Complications

1. Surgical site infection: 998.5
2. Surgical site wound: 998.30, 998.31, 998.32, 998.33
3. Surgical site seroma: 998.13
4. Surgical site hematoma: 998.12
5. Surgical site nonhealing wound: 998.83
6. Hemorrhage complicating a procedure: 998.11

Appendix E6. Coding Used to Identify Iatrogenic Surgical Complications

New nerve injury

1. Diagnosis codes: 955.1, 955.2, 955.3, 955.4, 955.5, 955.6, 955.7, 955.8, 955.9
2. Current procedural terminology (CPT) codes: 64856, 64857

New blood vessel injury

1. Diagnosis codes : 903.2, 903.3, 903.4, 903.5, 903.8, 903.9, 997.79
2. CPT codes: 35206, 35207

New tendon injury

1. Diagnosis codes: 998.2
2. CPT codes: 26350, 26356

Iatrogenic injury

1. Diagnosis codes: 998.2, E870-E876
2. CPT codes: 64856, 64857, 35206, 35207, 37618, 26356, 26350

Note: Nerve injuries, blood vessel injuries, or tendon injuries are only counted after surgery if the patient does not have the same injury coded in the 90 days prior to the index date. Injuries coded on the surgery date are counted as after the index date. Additionally, only procedures on provider non-assistant claims were identified.

TABLE E1. Multivariable Logistic Regression Model for All-Cause 90-Day Postoperative Admission

Variable*	Odds Ratio	95% Wald Confidence Limits		*P* Value
		Lower Limit	Upper Limit	
Surgical setting (PR vs OR)	0.78	0.64	0.95	**<.05**
Elixhauser comorbidity index variables†	-	-	-	-
Anemia	3.14	2.18	4.50	**<.05**
Chronic pulmonary disease	2.64	2.05	3.41	**<.05**
Depression	1.59	1.14	2.24	**<.05**
Diabetes	1.80	1.53	2.11	**<.05**
Hypertension	1.53	1.30	1.81	**<.05**
Neurological disorders	2.54	1.61	4.01	**<.05**
Psychological disorders/psychosis	1.62	1.17	2.26	**<.05**
Solid tumor without metastasis	1.82	1.23	2.72	**<.05**
Region (vs North Central)	-	-	-	-
Northeast	0.64	0.51	0.81	**<.05**
South	0.86	0.73	1.02	.08
West	0.85	0.68	1.06	.14

The bolded *P* values are statistically significant.

*The following additional variables were included in the model but eliminated through a backward term-selection method: age, hypothyroidism, obesity, and smoking.

†The following Elixhauser comorbidity index variables were not analyzed in this model because of insignificance in the univariate analysis ($P > .10$): AIDS, alcohol abuse, chronic blood loss anemia, chronic kidney disease, coagulopathy, congestive heart failure, drug abuse, fluid and electrolyte disorders, liver disease, lymphoma, metastatic cancer, paralysis, peripheral vascular disease, pulmonary circulation disease, valvular disease, and weight loss. The following demographic variables were not analyzed in this model because of insignificance in the univariate analysis ($P > .10$): insurance type, residence type, and sex.