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Original Research

Chronic Steroid Use, Complications, and Readmission Following Open Reduction Internal Fixation of Distal Radius Fracture

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Purpose: The increasing incidence of both distal radius fractures (DRFs) and chronic conditions that necessitate long-term steroid use has resulted in a growing intersection between the patient populations of the two. Chronic steroid use is known to increase bone frailty and the likelihood of fractures but may also contribute to poorer outcomes following the repair of DRF. The purpose of this study was to investigate the association between preoperative chronic steroid use, postoperative complications, and readmission after open reduction internal fixation (ORIF) of DRF.

Methods: The American College of Surgeons National Surgical Quality Improvement database was queried for all patients who underwent DRF ORIF between 2015 and 2021. However, 30-day postoperative complications after DRF ORIF were collected. Multivariate logistic regression analysis was conducted to investigate the relationship among preoperative chronic steroid use, postoperative complications, and patient factors associated with readmission.

Results: The postoperative complications associated with the steroid cohort were categorized as major, minor, and overall complications. Additionally, pneumonia, stroke, myocardial infarction, bleeding transfusions, deep vein thrombosis, pulmonary embolism, readmission, non-home discharge, and mortality were recorded. Chronic steroid use was found to be independently associated with major , minor, and overall complications, deep vein thrombosis, and readmission. Further investigation of readmission showed that male sex and comorbid chronic obstructive pulmonary disease were the only two patient factors independently associated with a greater likelihood of readmission after DRF ORIF.

Conclusions: Preoperative chronic steroid use was associated with an increasing rate of postoperative complications after DRF ORIF. Male sex and comorbid chronic obstructive pulmonary disease were characteristics of chronic steroid-use patients independently associated with increased risk of readmission after DRF ORIF. A better understanding of preoperative chronic steroid use as a risk factor for postoperative complications may allow surgeons to improve preoperative risk stratification and patient counseling in the management of DRF.

Type of study/level of evidence: Prognostic III.

Distal radius fractures (DRFs) account for up to 17.5% of fractures in adults and are one of the most common orthopedic injuries treated in the medical setting.[1] Increasing obesity and life expectancy are thought to contribute to the growing incidence of DRF.[2,3] Although sustained by all age groups, the bimodal distribution of DRF concentrates within the pediatric and elderly population.[4,5] Fractures that cannot undergo successful closed reduction are typically indicated for surgical intervention, which includes external fixation, percutaneous pinning, and open reduction internal fixation (ORIF). At the expense of other treatment options, the rate of ORIF has grown

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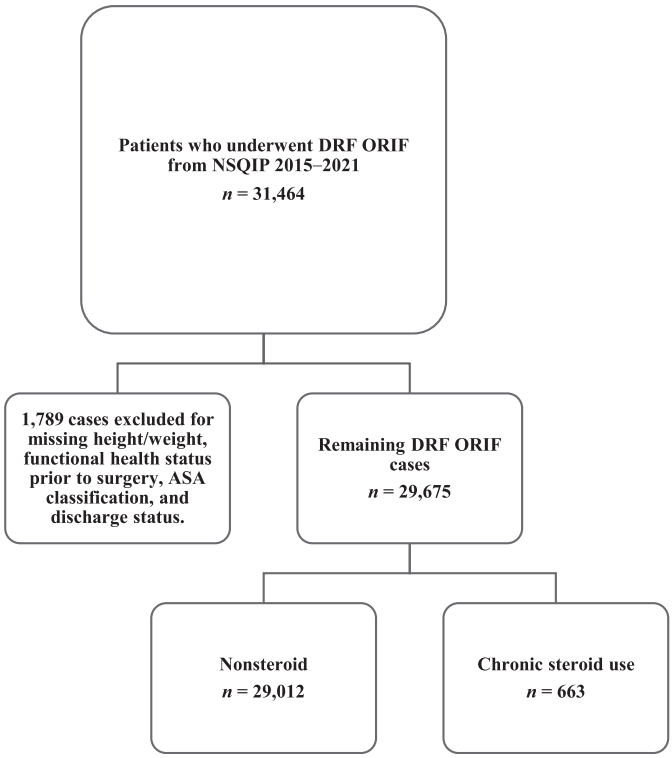

Figure. Case selection schematic. CPT, Current Procedural Terminology.

as the preferred method for addressing DRFs, increasing in use by 13% in the United States from 2010 to 2015.[6] The greater incidence of DRF ORIF has concentrated primarily in patients aged ≥65 years, warranting further investigation into the outcomes of a population at higher risk of complications after orthopedic procedures.[7]

DRFs and other upper-extremity fractures in adults often result from low-energy falls from standing height, characterized as fragility fractures.[8] The prevalence of musculoskeletal injuries, such as DRF, in the older population may be explained by several risk factors, such as older age, female sex, metabolic bone disease, active lifestyle, and dangerous living environments.[2,9,10] Steroid therapy is often indicated for many chronic conditions, including neoplasia, chronic obstructive pulmonary disease (COPD), and autoimmune disease.[11,12] Although steroid therapy is the standard of care for many of these conditions, long-term use can lead to adrenal insufficiency, hypertension, reduction in bone mineral density, and immunosuppression.[13]

The greater risk of postoperative complications secondary to chronic steroid usage is well documented in hand surgery, notably within total joint arthroplasty and lumbar procedures.[14–16] These reports have noted long-term steroid use to be associated with infection, thromboembolic events, greater length of hospital stay, and readmission. Similar studies have also focused on the complications distinct to ORIF procedures, finding low rates of early complications among the general cohort.[17,18] However, there exist no studies exist exploring the role of chronic steroid use related to complications and readmissions following DRF ORIF.

The goal of this study was to delineate the postoperative complications and investigate factors related to readmission after DRF ORIF in patients chronically using steroids. We hypothesized that chronic steroid use is an independent risk factor for a greater number and rates of postoperative complications.

Materials and Methods

We queried the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database for all patients who underwent ORIF of DRF between 2015 and 2021. This study was exempt from approval by our University's Institutional Review Board because the NSQIP database is fully deidentified. Data in the NSQIP database were obtained from more than 600 hospitals in the United States and were collected by trained Surgical Clinical Reviewers. The data are periodically audited to maintain high fidelity.

The Current Procedural Terminology codes 25607, 25608, and 25609 were used to identify 31,464 patients who underwent ORIF of DRF between 2015 and 2021. The exclusion criteria inherent to the NSQIP database inherently exclude all cases for patients aged <18 years and cases with primary admission related to trauma. Cases were excluded if any of the following variables had missing information: height/weight (1,259 excluded), discharge destination (12 excluded), American Society of Anesthesiologists (ASA) classification (38 excluded), and functional health status (480 excluded). A total of 1,789 patients were excluded based on these criteria.

The remaining study population of 29,675 (Fig.) was then divided into the nonsteroid cohort (n = 29,012) and the chronic steroid-use cohort (n = 663). Chronic steroid use was defined as patients who routinely took oral or parenteral immunosuppressants or corticosteroids within 30 days preprocedure. Patients who had a short-term use of steroids over the span of 10 days or less during the 30-day preoperative period were not classified as chronic steroid users and thus were included in the nonsteroid cohort. Moreover, patients who received corticosteroids not orally or parenterally (eg, intradermally, inhaled, etc.) were not classified as chronic steroid users and were included in the nonsteroid cohort.

Variables collected in this study included patient demographics, comorbidities, surgical characteristics, and 30-day postoperative complication data. Patient demographics included sex, body mass index (BMI), age, smoking status, functional status, and ASA classification. Smoking status was defined as smoking cigarettes at any point within the past year before the procedure. Preoperative comorbidities included congestive heart failure (CHF), diabetes, hypertension, COPD, bleeding disorders, and disseminated cancer. Complications that occurred within 30 days after surgery were included in the analysis. These complications included sepsis, septic shock, pneumonia, reintubation, urinary tract infection, stroke, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, blood transfusions within 72 hours after surgery, deep vein thrombosis (DVT), pulmonary embolism (PE), failure to wean off a ventilator within 48 hours, deep incisional surgical space infection (SSI), superficial incisional SSI, organ/space SSI, wound dehiscence, readmission, reoperation, nonhome discharge, and mortality. Major complications included the following: cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, DVT, stroke, unplanned intubation, PE, failure to wean off the ventilator within 48 hours, sepsis, septic shock, deep incisional SSI, organ/space SSI, readmission, reoperation, and mortality. Minor complications included the following: pneumonia, urinary tract infection, blood transfusions within 72 hours after surgery, wound dehiscence, and superficial incisional SSI.

Patient demographics and comorbidities were compared between cohorts using bivariate logistic regression. Multivariate logistic regression, adjusted for all significantly associated patient demographics and comorbidities for the respective cohort, was used to identify independent associations between preoperative chronic steroid use and postoperative complications. Odds ratios (ORs) were reported with 95% confidence intervals (CIs). The level of statistical significance was set at P value of <.05.

Table 1
Patient Demographics and Comorbidities for Patients With and Without Chronic Steroid Use*

Demographic/Comorbidity Factor	Nonsteroid		Chronic Steroid		
	Number	Percent (%)	Number	Percent (%)	*P* Value
Overall	29,012	100.0	663	100.0	
Sex					**<.001**
Female	21,105	72.7	557	84.0	
Male	7,907	27.3	106	16.0	
Age (y)					**<.001**
18–39	5,286	18.2	34	5.1	
40–64	13,805	47.6	285	43	
65–74	6,388	22	212	32	
≥75	3,533	12.2	132	19.9	
BMI (kg/m^2)					**<.001**
<18.5	18,814	64.8	383	57.8	
18.5–29.9	555	1.9	16	2.4	
30–34.9	5,575	19.2	144	21.7	
35–39.9	2,347	8.1	61	9.2	
≥40	1,721	5.9	59	8.9	
Functional status before surgery					**.030**
Dependent	417	1.4	17	2.6	
Independent	28,595	98.6	646	97.4	
ASA classification					**<.001**
≤2	21,123	72.8	257	38.8	
≥3	7,889	27.2	406	61.2	
Smoker					.086
No	23,890	82.3	563	84.9	
Yes	5,122	17.7	100	15.1	
Comorbidities					
CHF	119	0.4	9	1.4	**<.001**
Diabetes mellitus	2,388	8.2	97	14.6	**<.001**
Hypertension	9,019	31.1	368	55.5	**<.001**
COPD	893	3.1	96	14.5	**<.001**
Bleeding disorder	548	1.9	52	7.8	**<.001**
Disseminated cancer	46	0.2	14	2.1	**<.001**

* Bold *P* values indicate statistical significance with $P < .05$.

Results

Compared with the nonsteroid cohort, the chronic steroid-use cohort was statistically significant for female sex ($P < .001$), older (aged 65–74 years and ≥ 75 years) age groups ($P < .001$), higher BMI groups ($P < .001$), dependent functional health status ($P = .030$), ASA classification ≥ 3 ($P < .001$), and comorbid CHF ($P < .001$), diabetes ($P < .001$), hypertension ($P < .001$), COPD ($P < .001$), bleeding disorders ($P < .001$), and disseminated cancer ($P < .001$; Table 1).

Compared with the nonsteroid cohort, the chronic steroid-use cohort was found to have an association with the following 30-day postoperative complications: major complications ($P < .001$), minor complications ($P < .001$), overall complications ($P < .001$), pneumonia ($P < .001$), cardiac arrest ($P = .048$), myocardial infarction ($P = .019$), blood transfusions ($P < .001$), DVT ($P < .001$), PE ($P = .028$), readmission ($P < .001$), nonhome discharge ($P < .001$), and mortality ($P = .040$) (Table 2). Of note, compared with the nonsteroid cohort, the chronic steroid cohort was not found to be significantly associated with deep incisional ($P = .271$), superficial incisional ($P = .098$), and organ/space SSI ($P = .999$), as well as wound dehiscence ($P = .999$).

After controlling for all significant patient demographic and comorbidity factors, an adjusted multivariate regression analysis was conducted (Table 3). Compared with the nonsteroid cohort, the chronic steroid use cohort was independently associated with a greater likelihood of major complications (OR, 1.73; 95% CI, 1.17–2.55; $P = .006$), minor complications (OR, 1.81; 95% CI, 1.09–3.00; $P = .021$), overall complications (OR, 1.72; 95% CI, 1.23–2.42; $P = .002$), DVT (OR, 4.41; 95% CI, 1.12–17.30; $P = .034$), and readmission (OR, 1.79; 95% CI, 1.19–2.70; $P = .005$).

The significant association between chronic steroid use and readmission was further explored to find patient characteristics of chronic steroid users associated with a greater likelihood of readmission. This was accomplished using a backward stepwise approach that isolated chronic steroid-use patients and subsequently used multivariate logistic regression to identify patient characteristics related to readmission (Table 4). Male sex (OR, 3.72; 95% CI, 1.60–8.61; $P = .002$) and comorbid COPD (OR, 3.84; 95% CI, 1.47–10.07; $P = .006$) were found to be the only 2 patient factors independently associated with a greater likelihood of readmission.

Finally, the reasons for readmission in the patients chronically using steroids were summarized (Table 5). Nonsurgical site-related reasons for readmission (76.9%) were more common than surgical site-related reasons (11.5%). Among nonsurgical site-related reasons for readmission, pulmonary complications (23.1%) and cardiovascular complications (15.4%) were the most common. Specifically, pulmonary complications were comprised of PE (11.5%), shortness of breath (7.7%), and respiratory failure with hypoxia (3.8%). Cardiovascular complications were comprised of myocardial infarction (7.7%), CHF (3.8%), and unspecified tachycardia (3.8%). Among surgical site-related reasons for readmission, pain (3.8%), fracture-related complications (3.8%), and soft tissue complications (3.8%) were equally common.

Discussion

As the number of ORIF procedures to treat DRF increases, an exploration into associated outcomes of at-risk groups may guide treatment choice and allow for better preoperative counseling. Those using a long-term regimen of steroids may experience deleterious side effects, contributing to complications after surgery.

Table 2
Bivariate Analysis of 30-Day Postoperative Complications in Patients With and Without Chronic Steroid Use*

Complication	Nonsteroid		Chronic Steroid		
	Number	**Percent (%)**	**Number**	**Percent (%)**	***P* Value**
Major complications	413	1.4	31	4.7	**<.001**
Minor complications	241	0.8	18	2.7	**<.001**
Overall complications	601	2.1	42	6.3	**<.001**
Sepsis	16	0.1	0	0.0	.999
Septic shock	7	0.0	1	0.2	.086
Pneumonia	36	0.1	5	0.8	**<.001**
Reintubation	14	0.0	1	0.2	.271
Urinary tract infection	91	0.3	5	0.8	.056
Stroke	10	0.0	0	0.0	.999
Cardiac arrest	5	0.0	1	0.2	**.048**
Myocardial infarction	15	0.1	2	0.3	**.019**
Blood transfusions	33	0.1	5	0.8	**<.001**
DVT	14	0.0	3	0.5	**< 0.001**
PE	17	0.1	2	0.3	**.028**
Failure to wean off ventilator	5	0.0	0	0.0	.999
Deep incisional SSI	14	0.0	1	0.2	.271
Superficial incisional SSI	75	0.3	4	0.6	.098
Organ/space SSI	13	0.0	0	0.0	.999
Wound dehiscence	11	0.0	0	0.0	.999
Readmission	367	1.3	28	4.2	**<.001**
Reoperation	246	0.8	10	1.5	.073
Nonhome discharge	708	2.4	44	6.6	**<.001**
Mortality	19	0.1	2	0.3	**.040**

* Bold *P* values indicate statistical significance with $P < .05$.

Table 3
Multivariate Analysis of 30-Day Postoperative Complications in Patients With and Without Chronic Steroid Use*

Complication	OR, (95% CI); *P* Value
Major complications	1.73, 1.17–2.55; **.006**
Minor complications	1.81, 1.09–3.00; **.021**
Overall complications	1.72, 1.23–2.42; **.002**
Pneumonia	2.35, 0.88–6.27; .089
Cardiac arrest	2.11, 0.23–19.31; .510
Myocardial infarction	2.15, 0.43–10.88; .353
Blood transfusions	2.69, 1.00–7.22; .050
DVT	4.41, 1.12–17.30; **.034**
PE	1.89, 0.40–8.95; .423
Readmission	1.79, 1.19–2.70; **.005**
Nonhome discharge	1.26, 0.90–1.77; .178
Mortality	1.58, 0.36–7.00; .544

* Bold *P* values indicate statistical significance with $P < .05$.

Table 4
Significant Patient Demographic and Comorbidity Predictors for 30-Day Readmission in Chronic Steroid Use Patients

Demographic/Comorbidity Factor	OR, 95% CI; *P* Value
Gender	
Female	Reference
Male	3.72, 1.60–8.61; .002
COPD	
No	Reference
Yes	3.84, 1.47–10.07; .006

In this study, we found that preoperative chronic steroid use is an independent predictor of major, minor, and overall complications, DVT, and readmission within 30 days of DRF ORIF. We also found that in patients who were chronically using steroids before DRF ORIF, men and those with comorbid COPD were independently more likely to be readmitted within 30 days.

Overall, patients with chronic steroid usage tended to be women, older, of higher ASA classification, dependent functional status, greater BMI, and have increased rates of comorbidities. These demographics are consistent with pre-existing orthopedic literature.[14,15,19,20] Reduction in bone mass and perturbation of systemic bone structure may contribute to the fragility and increased likelihood of DRF fracture in the elderly population. Studies have found that women aged >50 years experience approximately twice the rate of fracture injuries than men, partly because of their naturally lower bone density and increased propensity to develop osteoporosis.[21] The authors of another study noted that 85.4% of the 939,448 patients with DRF aged >65 years were woman.[2] In the present study, women with DRF comprise most of our nonsteroid (72.7%) and steroid cohorts (84.0%). Although the database does not provide information regarding patient osteoporotic status or bone density, the association of chronic steroid use with decreased bone strength and susceptibility may further bone weakness in a population of predominantly postmenopausal women already at increased risk of fractures.[22]

Corticosteroids may serve as treatment for autoimmune conditions, such as rheumatoid arthritis and systemic lupus erythematosus, as well as provide pain relief through their attenuation of the inflammatory response. Within the body, they can inhibit the production of prostaglandins and directly alter gene transcription of inflammatory and chemotactic cytokines, such as interleukin 1a and tumor necrosis factor.[23] This may lead to a reduction of neutrophils capable of presenting to the site of infection as well as macrophages that aid clearance of pathogens. Infections of pneumonia occur at greater rates in populations with long-term inhaled corticosteroid use, such as those with asthma or COPD.[24,25] In the present study, 0.8% of the chronic steroid usage cohort experienced postoperative pneumonia. After multivariable analysis, chronic steroid usage was found to be an independent risk factor for both pneumonia and readmission. Pre-existing literature in total shoulder arthroplasty (TSA) supports this finding, describing pneumonia as the most common reason for postoperative readmission in chronic steroid patients.[14] Postoperative pneumonia complications promote a high degree of morbidity and mortality in surgical procedures.[26] Our findings encourage the consideration of chronic steroid use as a factor that may put patients at higher risk of developing postoperative pneumonia.

Table 5
Reasons for 30-Day Readmission in Patients With and Without Chronic Steroid Use After DRF ORIF

Complication Category	Nonsteroid		Chronic Steroid	
	Number	Percent (%)	Number	Percent (%)
Total	234	100.0	26	100.0
Nonsurgical site-related	145	62.0	20	76.9
Pulmonary complications	12	5.1	6	23.1
Thromboembolic complications	7	3.0	2	7.7
Renal complications	15	6.4	2	7.7
Unrelated orthopedic complications	17	7.3	1	3.8
Cardiovascular complications	30	12.8	4	15.4
Gastrointestinal complications	21	9.0	2	7.7
Neurological complications	26	11.1	2	7.7
Other Infectious complications	17	7.3	1	3.8
Surgical site related	7	3.0	3	11.5
Pain	0	0.0	1	3.8
Fracture-related complications	5	2.1	1	3.8
Soft tissue complications	2	0.9	1	3.8
Other complications/unspecified	82	35.0	3	11.5

Our study discovered several cardiovascular and thromboembolic complications independently associated with chronic steroid users undergoing ORIF for DRF, including cardiac arrest, myocardial infarction, DVT, and PE. Pre-existing literature has established a relationship between steroid use and venous thromboembolism.[27] Although significant patient risk factors are considered an indication for venous thromboembolism in upper-extremity surgery, there still exists less consistent guidelines for venous thromboembolism prophylaxis in upper-extremity surgeries compared with lower-extremity surgeries.[28,29] Therefore, our findings support the incorporation of chronic steroid use as an indication for venous thromboembolism prophylaxis in upper-extremity surgery. Large longitudinal studies have concluded that chronic corticosteroid therapy, even at low dosages, can elicit cardiovascular diseases, such as atrial fibrillation, heart failure, myocardial infarction, and peripheral arterial disease in individuals with immune-related diseases.[30]

Furthermore, large database studies in neurological surgery report prolonged corticosteroid use to be associated with DVT and PE.[31] Within orthopedics, studies in total hip arthroplasty found increased thromboembolic events in chronic steroid users.[20] The result of our analysis emphasizes the importance of identifying patients with long-term steroid usage in risk stratification to mitigate cardiovascular and thromboembolic complications.

The aforementioned benefits of corticosteroids effectively hinder the neutrophilic infiltration of wounds through the downregulation of recruitment factors and adhesion molecules on the endothelium.[13] Later in the proliferative phase of healing, fibroblast proliferation, fibrin formation, and collagen accumulation are markedly impaired by steroid usage, increasing the risk for postoperative infection and wound dehiscence.[23,32] Interestingly, our study found that 0.2%, 0.6%, and 0% of chronic steroid users experienced deep incisional, superficial incisional, and organ/space surgical site infections, respectively. No patients within the chronic steroid cohort experienced wound dehiscence. In addition, following the adjustment of demographics and comorbidities, chronic steroid usage was not found to be independently associated with any degree of infection. Similar studies of the upper extremity reported no independent association of chronic steroid usage with surgical site infections or wound dehiscence after TSA.[14] These findings support pre-existing orthopedic literature, which has noted that chronic steroid use is not independently associated with superficial or organ site infections in lumbar decompression surgery or revision total knee arthroplasty.[16,33]

Mortality was observed in 2 of the 663 identified chronic steroid users and was found to be significantly associated with chronic steroid use after multivariate analysis. We are unable to determine the cause of mortality based on the data provided and only speculate its relation to postoperative complications. Furthermore, mortality is a rare complication of ORIF procedures.[17]

We found long-term steroid use to be independently associated with readmission within 30 days of DRF ORIF. In general, DRF ORIF unplanned readmission rate is lower than that of other orthopedic procedures.[34] Another study using the NSQIP database found that in a cohort of 11,124 patients undergoing DRF ORIF, 196 (1.76%) were readmitted. Our nonsteroid cohort saw a similar unplanned readmission rate of 1.3%. In contrast, the rate of unplanned readmissions after DRF ORIF in the chronic steroid cohort was 4.2%. Related studies isolating chronic steroid users have found that unplanned readmission is significantly associated with steroid-use status and is a costly complication to both patient satisfaction and hospital finances.[14,15,35] Reoperation often accompanies readmission since readmission is generally required for reoperation after DRF. Interestingly, our study found no significant difference in the rate of reoperation between steroid and nonsteroid groups, suggesting that the difference in readmission rates is likely related to other sequelae of chronic steroid use unrelated to surgical site and hardware complications.

Upon investigating patient characteristics of chronic steroid patients that are independently linked with readmission, we identified both males and comorbid COPD as risk factors. These findings are consistent with a study on readmission factors after TSA, which found that COPD is an independent risk factor for readmission after TSA in a cohort of chronic steroid patients.[14] Regarding the reasons for readmission, we found that nonsurgical site-related complications were more common than surgical site-related complications. This pattern of readmission predominantly because of causes not directly related to the operation itself is consistent with pre-existing literature in orthopedic readmission rates following both TSA and DRF treatment.[14,36] Finally, the most notable difference in reasons for readmission between the chronic steroid and nonsteroid group was for pulmonary complications. This is likely explained by the high rate of comorbidity that chronic steroid patients have with severe COPD, a known risk factor for postoperative complications and readmissions following DRF ORIF.[37]

Our findings are met by several limitations. The postoperative complications provided by the NSQIP database occur within a 30-day period exclusively, limiting the ability to explore long-term

complications, such as functionality, chronic pain, and refracture. Importantly, the database does not provide reasoning for chronic steroid use, which may contribute to the complications observed in that respective patient cohort. Next, we were limited by the variables provided by the database, so we were unable to investigate certain outcomes specific to steroid use, such as bone mineral density. Furthermore, the database lacks information related to concurrent medication use, which limits our ability to subclassify or exclude patients based on short-term steroid use and nonsystemic route of administration (eg, nonparaenteral injections). Next, of the patients with COPD in our study, 9.7% routinely took systemic steroids. Because patients with more severe COPD require oral corticosteroids, this likely sicker population may introduce confounding bias that may only be partially rectified via multivariate analysis. Finally, the NSQIP database excludes cases with primary admission related to trauma. Because DRF is often seen in patients experiencing polytrauma, our study population consists of patients who likely experienced DRF secondary to low-energy fractures or isolated trauma. Despite these limitations, our study is strengthened by the comprehensive and representative amount of information provided by the NSQIP database. The information presented contributes to the growing evidence supporting careful attention to chronic steroid users during risk stratification prior to orthopedic procedures to better select surgical candidates and reduce the rates of both postoperative complications and readmission.

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