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Original Research

Foregoing Preoperative Antibiotics in Clean, Implant-Based Hand Surgery Does Not Increase Postoperative Infectious Risks

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Purpose: Although data support foregoing preoperative antibiotics for outpatient, soft-tissue procedures, there is a paucity of evidence regarding antibiotics for implant-based hand procedures. The purpose of this investigation was to assess early postoperative infectious concerns for patients undergoing implant-based hand surgery, regardless of preoperative antibiotic use.

Methods: A retrospective cohort analysis was performed consisting of all patients undergoing implant-based hand procedures between January 2015 and October 2021. Primary outcomes included antibiotic prescription or reoperation for infection within 90 days of surgery. Demographics (age, gender, body mass index, diabetes, and smoking status) and hand surgery procedure type were recorded. To account for differences in baseline characteristics between patients who did and did not receive preoperative antibiotics, covariate balancing was performed with subsequent weighted logistic regression models constructed to estimate the effect of no receipt of preoperative antibiotics on the need for postoperative antibiotics. In a separate logistic regression analysis, patients' baseline characteristics were evaluated together as predictors of postoperative antibiotic prescription.

Results: One thousand eight hundred sixty-two unique procedures were reviewed with 1,394 meeting criteria. Two hundred thirty-six patients (16.9%) were not prescribed preoperative antibiotics. Overall, 54 (3.87%) and 69 (4.95%) patients received antibiotics within 30 and 90 days of surgery, respectively. One patient (0.07%) underwent reoperation. There were no differences in the rates of 30- and 90-day postoperative antibiotic prescriptions between the two groups. After covariant balancing of risk factors, patients not prescribed preoperative antibiotics did not display significantly higher odds of requiring postoperative antibiotics at 30 or 90 days. Logistic regression models showed male gender, temporary Kirschner wire fixation, and elevated body mass index were associated with increased postoperative antibiotics at 30 and 90 days.

Conclusions: For implant-based hand procedures, there was no increased risk in postoperative antibiotic prescription or reoperation for patients who did not receive preoperative antibiotics.

Type of study/level of evidence: Therapeutic III.

Preoperative antibiotic prophylaxis is a key component for the prevention of surgical site infections.[1] However, evidence suggests that routine antibiotic prophylaxis may not be required for specific soft-tissue procedures in the hand and upper extremity. Multiple studies suggest that antibiotic prophylaxis does not reduce the incidence of postoperative infections after clean, short duration, soft-tissue hand procedures.[2–4] In response, the American Society of Health-System Pharmacists no longer recommends prophylactic antibiotics prior to clean hand surgeries without permanently imbedded implants.[5]

The use of antibiotic prophylaxis involving hardware and other foreign implantable materials remain controversial. In a survey to

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Table 1
Common Procedure Terminology Codes for Included Cases

Procedure	CPT
Treatment of distal radius fracture	25607, 25608, 25609
Treatment of scaphoid fracture	25628
Thumb CMC arthroplasty	25447
Treatment of phalangeal or metacarpal fracture or dislocation	26727, 26735, 26608, 26615, 26706, 26650, 26715, 26756, 26746, 26676, 26665, 26676, 26685, 26686
Digit, hand, or wrist fusion procedure	25820, 25800, 26860, 26861, 26843

CMC, carpometacarpal; CPT, Common Procedure Terminology.

Table 2
Attending Surgeon and Tendency to Prescribe Patients Preoperative Antibiotics

Attending Surgeon	Overall, n (%)	Preoperative Antibiotics	
		No (n = 236)	Yes (n = 1,158)
1	391 (28)	231 (98)	160 (14)
2	221 (16)	2 (0.8)	219 (19)
3	189 (14)	3 (1.3)	186 (16)
4	205 (15)	0 (0)	205 (18)
5	388 (28)	0 (0)	388 (34)

members of the American Society for Surgery of the Hand, 5% of responders reported they never give preoperative antibiotics, and another 7% reported they would not give antibiotics in scenarios involving permanently or temporarily implanted hardware.[6] A subgroup analysis of a previous randomized controlled trial found that the use of antibiotics did not decrease surgical site infection rate for hand procedures involving implants or hardware.[7] However, the generalizability of this study has been criticized for excluding patients with comorbidities, such as diabetes. There is minimal available literature supporting the notion that preoperative antibiotics are required for clean procedures of the hand involving permanent and/or temporary implants and hardware. Additionally, previous guidelines by the American Society of Health-System Pharmacists refer to the need for antibiotic prophylaxis in hardware-based hand surgery as level C evidence, or expert opinion.[5]

The purpose of this investigation was to compare the rates for postoperative antibiotic prescriptions and return to the operating room for infection in patients who did and did not receive preoperative antibiotics for hand and wrist surgery involving hardware and other implantable devices. We aimed to test our null hypothesis that there was no difference in early reoperation or postoperative antibiotic prescription rates for patients who did not receive preoperative antibiotics compared to those who did receive preoperative antibiotics for their implant-based hand procedures.

Materials and Methods

Data collection

Our Institutional Review Board approved this retrospective study (approval number 2021-0950). Our institution's electronic health record was reviewed to identify and include all patients aged ≥18 years undergoing implant-based hand procedures from January 2015 to October 2021 at the initiation of the chart review. Procedures included were identified using Common Procedure Terminology codes (Table 1). Implants were defined as imbedded materials, including stainless steel, titanium, or polyetheretherketone (PEEK). For patients with two or more procedures during the study period, only their earliest surgery was included for analysis. All procedures were performed by one of five fellowship-trained hand surgeons (Table 2). Manual chart review was performed for each case to confirm all procedures included implants and to determine whether the implants were either temporary Kirschner wire (K-wires) or permanently imbedded. If a patient had a combination of percutaneous K-wires and permanently imbedded implants, the patient was placed into the permanently imbedded category. Of note, one of the five hand surgeons intermittently cut the K-wire(s) at the level of the skin with the intention of removing the K-wire(s) at a later date. These cases were still placed in the temporary percutaneous K-wire group.

Exclusion criteria consisted of polytrauma patients, patients with contaminated wounds or open fractures, patients who received antibiotics for reasons unrelated to the upper extremity procedure, including antibiotics from another medical team or the emergency department, and patients with less than two outpatient follow-up visits (Fig. 1). Primary outcomes were prescribed postoperative antibiotics and reoperation for surgical site–specific infectious concerns at 30 and 90 days after surgery. All 30-day antibiotic prescriptions were included in the 90-day antibiotic prescription calculation to represent a true 90 days. If a patient received a postoperative antibiotic for any reason, the patient's chart was flagged, and a more thorough chart review was performed to identify the prescriber, and the reason for the antibiotics. Surgical site–specific infectious concerns were determined by manual chart review of clinical notes, which included physical exam findings such as erythema, swelling, warmth and drainage, and antibiotic prescriptions from the hand surgical provider or care team.

Demographic information such as age at the time of surgery, gender as labeled in the electronic medical record, body mass index (BMI), diabetes (both type 1 and type 2), and smoking status were recorded and compared. Prophylactic preoperative antibiotic use was recorded based upon the presence of an intravenous antibiotic prescribed in the preoperative medications, with confirmed administration within 30 minutes of incision. Our null hypothesis aimed to test no difference in early reoperation or postoperative antibiotic prescription rates for patients who did not receive preoperative antibiotics compared to those who did.

Procedure type

Carpometacarpal arthroplasties were performed in two different fashions. The primary difference being whether a PEEK suture anchor (Arthrex) between the proximal thumb metacarpal and index metacarpal was placed. The PEEK suture anchor was the only type of suture anchor used in the series. If a patient did not receive a PEEK suture anchor but had a K-wire placed, they were placed in the temporary percutaneous K-wire fixation group. If a patient did receive a PEEK suture anchor, given the suture anchor permanently remained, they were placed into the permanent implant group. The surgeons included in this study do not perform total carpometacarpal joint replacements. The remaining procedures, treatment of distal radius fractures, treatment of scaphoid fractures, treatment of phalangeal and/or metacarpal fractures, were all of similar technique among the five surgeons. These procedures were grouped as either temporary percutaneous K-wire fixation or permanently imbedded hardware based upon chart review.

Statistical analysis

We compared baseline characteristics of patients who were prescribed preoperative antibiotics with those who were not

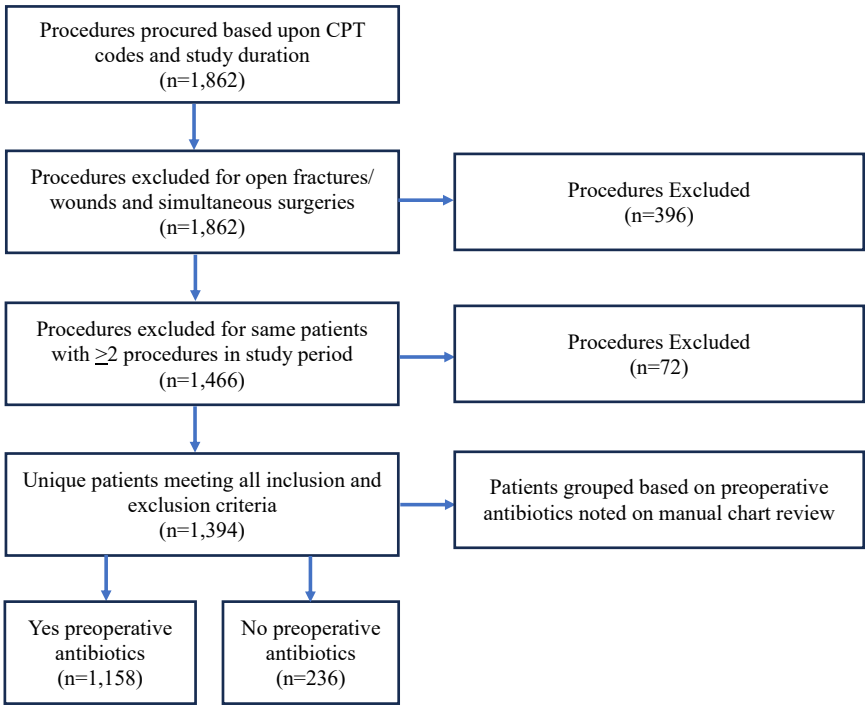

Figure 1. Flow diagram of applied inclusion and exclusion criteria. A total of 1,862 procedures were reviewed. After applying the initial exclusion criteria of open fractures, patients undergoing simultaneous surgeries with multiple specialties, and receiving antibiotics from other specialties, 1,466 procedures remained. After applying the second round of exclusion criteria of eliminating multiple surgeries of the same patient, we were left with 1,394 unique surgeries that also equaled 1,394 unique patients. These patients were then separated into those who did receive preoperative antibiotics (1,158) and those who did not receive preoperative antibiotics (236). CPT, Common Procedure Terminology.

Table 3
Demographics and Clinical Characteristics

Characteristic	Overall (N = 1,394)	Preoperative Antibiotics		*P* value*
		No (n = 236)	Yes (n = 1,158)	
Gender, n (%)				.080
Female	728 (52)	111 (47)	617 (53)	
Male	666 (48)	125 (53)	541 (47)	
Age at surgery (y), median (IQR)	51.8 (31.8–63.3)	49.7 (29.7–62.2)	52.2 (32.2–63.5)	.112
Hand surgery type, n (%)				<.001
Permanent implant	910 (65)	66 (28)	844 (73)	
Temporary K-wire	484 (35)	170 (72)	314 (27)	
BMI (kg/m^2), median (IQR)	28.0 (24.3–33.3)	28.3 (24.9–33.5)	27.9 (24.2–33.2)	.544
Diabetes, n (%)				.262
No	1,240 (89)	205 (87)	1,035 (89)	
Yes	154 (11)	31 (13)	123 (11)	
Current smoker, n (%)				.047
No	990 (71)	155 (66)	835 (72)	
Yes	404 (29)	81 (34)	323 (28)	

IQR, interquartile range.
* Pearson's chi-squared test; Wilcoxon rank sum test.

prescribed preoperative antibiotics. Categorical variables including gender, hand surgery type, diabetes, and smoking status were reported as frequencies and percentages. Continuous variables, including age at the time of surgery and BMI, were reported as median and interquartile range. For comparing categorical variables, Pearson's chi-squared tests were used. For comparing continuous variables, the Wilcoxon rank sum test was employed.

Given differences in baseline characteristics between the two treatment groups, we performed covariate balancing to avoid confounding the effect of foregoing preoperative antibiotics on the need for antibiotics at 30 and 90 days after surgery. All six patient characteristics or covariates (age, gender, BMI, hand surgery type, diabetes, and smoking status) contained in Table 3 were included in the covariate balancing. We used entropy balancing, which is a method for producing weights for each subject similar to inverse probability weighting. This method was used rather than inverse probability weighting because it achieved balance for all covariates (for continuous variables, standardized mean differences between treatment groups were less than 0.05; for binary variables, differences in proportions between treatment groups were also less than 0.05). These generated weights were then incorporated into logistic regression models to measure the relationship between no receipt of preoperative antibiotics and need for antibiotics at 30 and 90

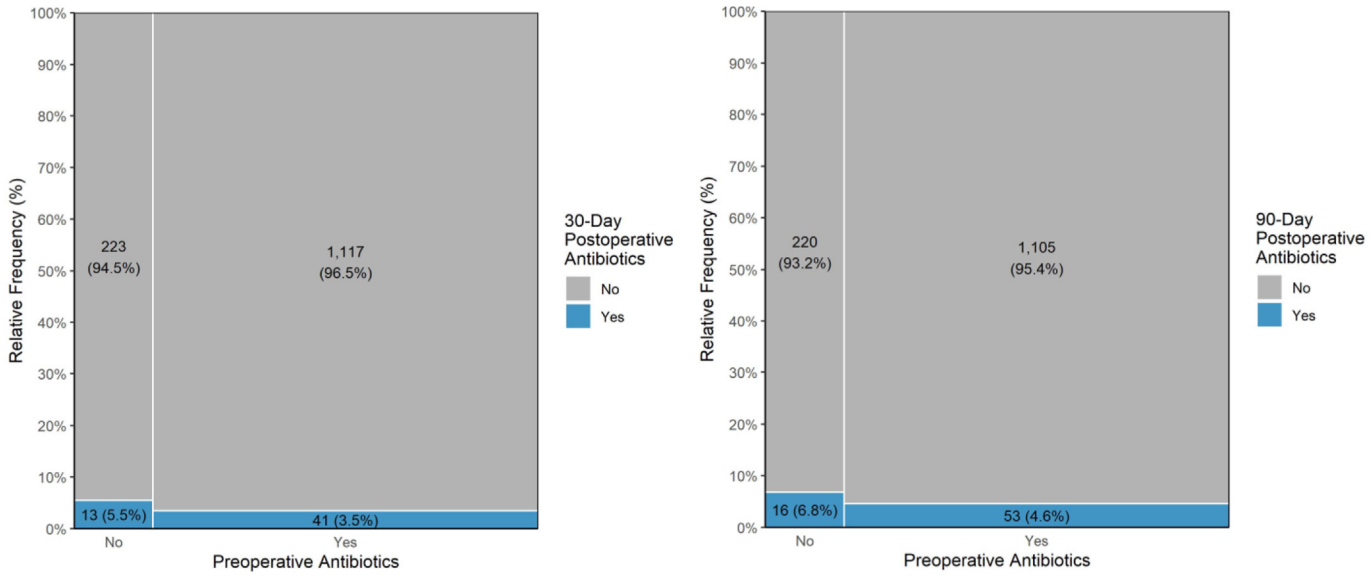

Figure 2. Thirty- and 90-day postoperative antibiotic prescription rates. The postoperative antibiotic prescription rate of patients receiving preoperative antibiotics (right column in both plots) compared with that of those who did not receive preoperative antibiotics (left column in both plots). Patients who did not receive a postoperative antibiotic are depicted in gray, and patients who did receive a postoperative antibiotic are depicted in blue. The plot on the left is 30 days after surgery, and the plot on the right is 90 days after surgery.

days. In separate multiple logistic regression models, we explored the predictiveness of the six baseline variables from Table 3 on the need for postoperative antibiotics at 30 and 90 days. Associated area under the curve statistics were calculated and reported.

Analyses were performed using statistical software to generate balancing weights, and the boot package was used to produce bootstrapped CIs. Results from logistic regression models were presented as odds ratios and 95% CIs. All statistical tests were two-sided, and a P value of <.05 was considered statistically significant.

Results

A total of 1,394 unique patients met both inclusion and exclusion criteria (Fig. 1). Overall, 1,158 patients (83%) received preoperative antibiotics. Demographic information is presented in Table 3. Compared to patients who received preoperative antibiotics, those not prescribed preoperative antibiotics were more likely to have undergone a percutaneous, temporary K-wire procedure ($P < .05$) and were more likely to be current smokers ($P \leq .05$).

Postoperative antibiotics were prescribed at a rate of 3.87% (n = 54) and 4.95% (n = 69) at 30 and 90 days, respectively, regardless of preoperative antibiotic status. For those who received preoperative antibiotics, postoperative antibiotics were prescribed at a rate of 3.5% (n= 41) and 4.6% (n = 53) at 30 and 90 days, respectively. For those who did not receive preoperative antibiotics, postoperative antibiotics were prescribed at a rate of 5.5% (n = 13) and 6.8% (n = 16) at 30 days and 90 days, respectively. There was no significant association between preoperative antibiotics status and need for postoperative antibiotics at 30 days ($P = .15$) or 90 days ($P = .16$) (Fig. 2). One patient from the non-preoperative antibiotic group (0.07% overall) returned to the operating room for irrigation and debridement; however, this data point was too small to evaluate for significance.

Covariate balancing was performed, and logistic regression models were constructed to estimate the effect of no preoperative antibiotics on the need for 30- or 90-day postoperative antibiotic prescription. Figure 3 displays the estimated odds ratios and bootstrapped 95% CIs from the two models. Patients not receiving preoperative antibiotics did not have significantly higher odds of requiring postoperative antibiotics at either 30 or 90 days.

Regardless of a patient's preoperative antibiotic status, patients' baseline characteristics were predictive of need for postoperative antibiotics at both 30- and 90-days after the procedure. The multiple logistic regression models containing the six predictor variables from Table 3 achieved areas under the curve of 0.72 and 0.70 for the need for postoperative antibiotics at 30- and 90-days, respectively. The areas under the curve obtained of around 0.70 indicate that these models have fair discrimination ability. Temporary percutaneous K-wire hand surgery, male gender, and elevated BMI were associated with increased need for postoperative antibiotic prescriptions at both 30 and 90 days (Fig. 4).

Discussion

This investigation demonstrated no difference in rates of reoperation and postoperative antibiotic prescriptions between patient groups that did and did not receive preoperative antibiotics prior to their hardware-based hand procedures. Traditionally, preoperative antibiotics are thought to be an integral part of perioperative patient care with implantable hardware.[5] Large joint and long bone fracture fixation studies have provided thorough evidence of the benefits of preoperative antibiotic usage in clean, implant-based surgery on the lower extremity, but there is a paucity of available evidence that definitively supports the need for preoperative antibiotics in clean, implant-based hand surgery.[8–10] We should not directly relate large joints of the lower extremity to the hand, as other previous studies, including Aydin et al[7] and Kistler et al,[11] have shown no significant difference in postoperative infection among patients undergoing upper extremity surgery regardless of whether they received preoperative antibiotics. Both studies included hardware and implantable devices, but these factors were only a small percentage of the studied groups.

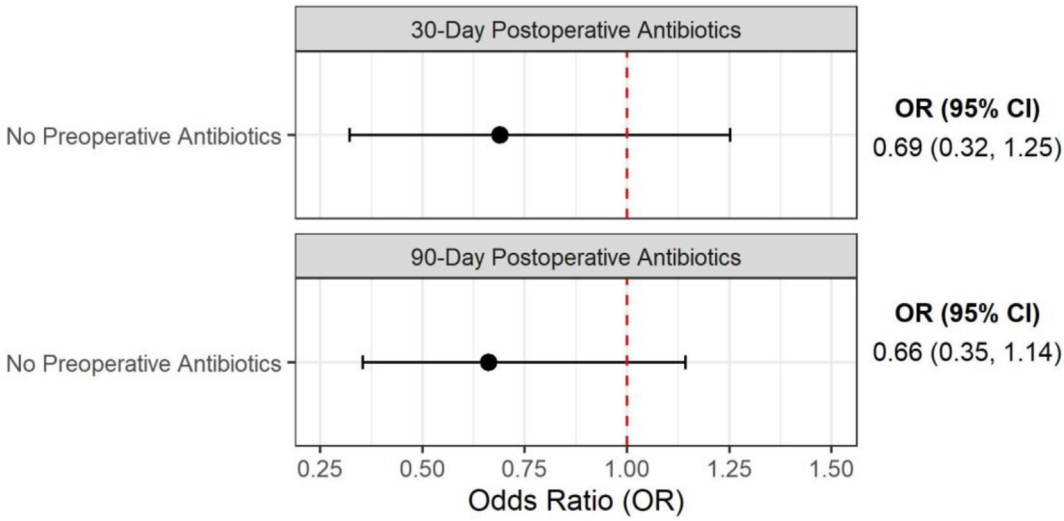

Figure 3. Odds of no preoperative antibiotics on the need for 30- and 90-day postoperative antibiotic prescription. Following covariate balancing, logistic regression models were constructed to estimate the effect of no preoperative antibiotics on the need for 30- or 90-day postoperative antibiotic prescription. Based on 95% CI data, patients not receiving preoperative antibiotics did not have significantly higher odds of requiring postoperative antibiotics at neither 30 or 90 days given that both 30- and 90-day CIs included ranges above and below the value of 1.00. OR, odds ratio.

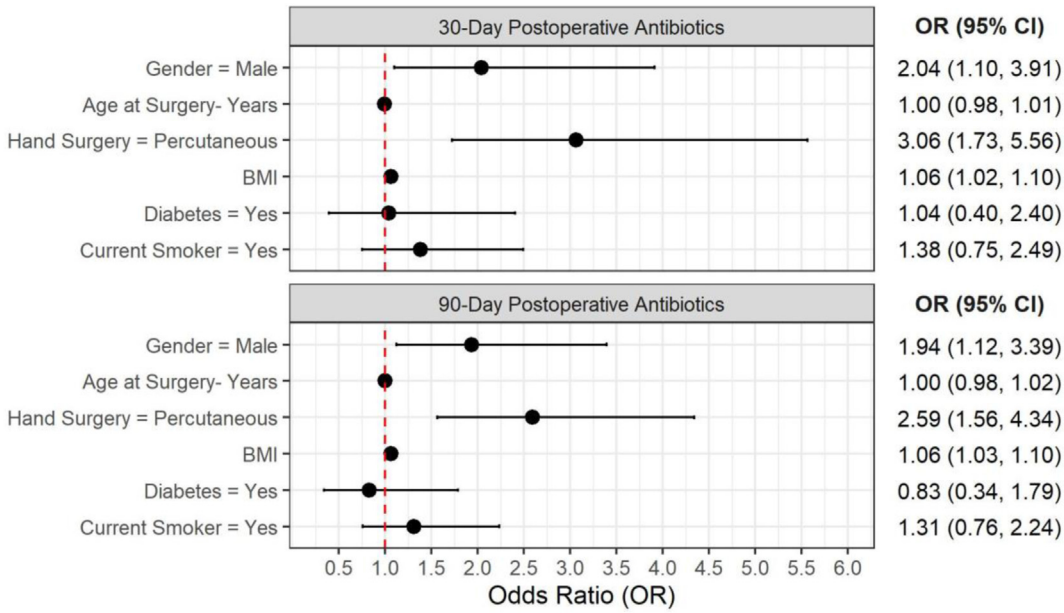

Figure 4. Patient characteristics and likelihood of postoperative antibiotic prescriptions. The six primary patient characteristics examined, including gender, age at time of surgery, hand surgery type, BMI, diabetes, and smoking status, were analyzed, and multiple logistic regression models were created. Temporary percutaneous K-wire hand surgery, male gender, and elevated BMI were associated with increased need for postoperative antibiotic prescriptions at both 30 and 90 days given that their 95% CIs were all above the value of 1.00. OR, odds ratio.

Our postoperative 30- and 90-day antibiotic prescription rates of 3.87% and 4.95%, respectively, are higher than the previously reported rates of 0.5% to 1% for general hand infections and 1.2% to 4% for implantable hardware infections.[6,12–17] This difference is primarily attributed to the fact our postoperative antibiotic prescription rate overestimates true postoperative surgical site infections. Other differences are likely due to variations in the definition of postoperative infection among studies. Postoperative antibiotic prescriptions and return to the operating room were chosen as primary outcomes because these are objective measures found in chart review. The previous literature reveals that the diagnosis of "postoperative infection" is unreliable in retrospective analyses, which was the primary reason that diagnosis was not used in this study.[18] If the surgeons were concerned for a postoperative infection, they would either prescribe antibiotics or take the patient to the operating room for irrigation and debridement. These two primary outcomes most likely overestimate the actual number of patients with postoperative infections, explaining our higher-than-expected infectious outcomes.

On multivariate analysis, temporary, K-wire fixation hand surgery, male gender, and elevated BMI were associated with

increased need for postoperative antibiotic prescriptions at both 30 and 90 days. Our findings differ from earlier published reports, which previously determined that smoking, diabetes, and procedure length increased a patient's risk of postoperative infection regardless of preoperative antibiotic status.[4] We did not evaluate procedure length, but both diabetes and smoking status were not found to significantly affect the postoperative prescription rate regardless of a patient's preoperative antibiotic status. Gender, a standard demographic data point for our institution, was not expected to show a difference within our study. We have no clinical explanation of why gender increased postoperative antibiotic prescriptions, and so additional, larger sample sizes are necessary to investigate this finding.

A separate analysis of patient characteristics for those who returned to the operating room was not performed as only one patient in the non-preoperative antibiotic group required unexpected irrigation and debridement. The patient underwent a temporary, K-wire fixation was obese and diabetic, with an elevated A1C. Our analysis of patient comorbidities showed elevated BMI increased a patient's risk for needing postoperative antibiotics, but the same could not be said for the diagnosis of diabetes. Previous studies have suggested that both obesity and diabetes are known risk factors for postoperative infections, but we did not observe this in our sample of patients.[4,16,19]

Limitations of this investigation include its retrospective design. Preventative, potentially standardized factors, such as skin preparation and surgical technique, can vary greatly from surgeon to surgeon in this multisurgeon study. Of the patients in the non-preoperative antibiotic group, 98% were treated by a single surgeon, which can limit the overall generalizability. This group also included more percutaneous K-wire procedures and smokers. Although a more uniform administration of non-preoperative antibiotic treatment among surgeons would have been more ideal, none of the other four surgeons used this practice prior to the initiation of the study given its novelty. In addition, there were general inconsistencies between surgeons and thresholds in prescribing postoperative antibiotics. Complications and infection rates are often underreported in retrospective studies, which is why we chose postoperative antibiotic prescription and reoperation as primary outcomes. Although these outcomes do not reflect the true definition of "postoperative infection," they allowed us to capture the greatest number of patients retrospectively. Although objective, these measurements most likely overestimate the true number of postoperative infections. We also did not specifically investigate whether patients were taking immunosuppressive mediations or had past medical histories supporting immune compromised states, which could affect their need for postoperative antibiotic therapy. The study is also potentially underpowered given that the overall rate of postoperative infection is incredibly low in hand surgery. Despite this study's limitations, these data may be useful for future systematic reviews seeking to answer questions that require large sample sizes because of low incidence.

Conflicts of Interest

No benefits in any form have been received or will be received related directly to this article.

Acknowledgments

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