Association of Drain Use in Ankle Arthrodesis With Increased Blood Transfusion Risk: A National Observational Study

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Abstract

Background: Closed wound drainage has been extensively studied in the hip and knee arthroplasty literature with equivocal results on its clinical benefits. Although also used in orthopaedic surgeries like ankle arthrodesis and ankle arthroplasty, large-scale data are currently lacking on utilization patterns and real-world effectiveness. We, therefore, aimed to address this research gap in this distinct surgical cohort using national claims data.

Methods: Using the Premier Healthcare claims database from 2006 to 2016, ankle arthrodesis (n=10,085) and ankle arthroplasty (n=4,977) procedures were included. The main effect was drain use, defined by detailed billing descriptions. Outcomes included blood transfusion, 90-day readmission, and length and cost of hospitalization. Mixed-effects models measured associations between drain use and outcomes. Odds ratios (OR, or % change), 95% CIs, and P values are reported.

Results: Overall, drains were used in 11% (n=1,074) and 15% (n=755) of ankle arthrodesis and ankle arthroplasty procedures, respectively. Drain use dramatically decreased over the years in both surgery types: from 14% to 6% and 24% to 7% between 2006 and 2016, for arthrodesis and ankle arthroplasty procedures, respectively. After adjustment for relevant covariates, drain use was associated with increased odds of blood transfusion in ankle arthrodesis surgery (OR 1.4, CI 1.1-1.8, P = .0168), whereas differences that were statistically but not clinically significant were seen in cost and length of stay. In total ankle arthroplasty, no statistically significant associations were observed between drain use and the selected outcomes.

Conclusion: This is the first national study on drain use in ankle surgery. We found a decrease in use over time. Drain use was associated with higher odds of blood transfusion in ankle arthrodesis patients. Although this negative effect may be mitigated by the rapidly decreasing use of drains, future studies are needed to discern drivers of drain use in this distinct surgical population.

Level of Evidence: Level III, retrospective cohort study

Keywords: arthrodesis, arthroplasty, drains, outcome

Introduction

Closed wound drainage has been long used in orthopaedic surgery because of the proposed benefit of reducing wound hematoma formation. Wound hematomas have been associated with decreased range of motion (ROM), delayed healing, and reoperation.1,3,8 Drain usage, however, may also increase infection risk by providing a conduit for skin flora into surgical sites and has been associated with an increased risk of blood transfusions.4,6,13,15,18,19,29 Furthermore, given...
the introduction of hemostatic agents like tranexamic acid (TXA), advances in surgical techniques, and improvement in surgical equipment, drain use in foot and ankle surgery has reduced.

There is a plethora of research evaluating drain usage in hip and knee arthroplasty, but there is a paucity of data on the benefits and harms of drains in other orthopaedic settings, including foot and ankle surgery. Ankle operations warrant special attention, as the skin around the ankle is often thin and prone to wound complications. Closed wound drainage is seen in total ankle arthroplasty (TAA) and ankle arthrodesis, but research evaluating drain use using large-scale data is yet to be seen.

There is no current consensus on drain use in ankle surgery, and the rate of utilization appears to be changing rapidly. Using national claims data, we, therefore, aimed to (1) describe utilization patterns of drain use in both ankle arthrodesis and TAA and (2) evaluate associations between drain use and outcomes. Specifically, we investigated the need for blood transfusions, length of stay (LOS), cost of hospitalization, and 90-day readmission.

Close examination of these outcomes may further provide clues to the utility and effect of drain use. We hypothesize that in our study we will see decreases in drain use over our study period and increases in our outcomes of interest in association with drains.

**Materials and Methods**

**Study Design**

This retrospective cohort study used deidentified data from the Premier Healthcare database (Premier Healthcare Solutions, Inc, Charlotte, NC), a national all-payer claims database that contains detailed billing information. Diagnoses and procedures were identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* codes (*ICD-9-CM*) for total ankle arthroplasty (81.11) and ankle arthrodesis (81.56) between 2006 and 2016 (Figure 1). The following exclusion criteria were applied: unknown gender (n=256), unknown discharge status (n=204), and nonelective procedure (n=3,308).
Study Variables

All the study variables were defined in an analysis plan, which was specified a priori. The main effect of interest was the use of closed wound drainage, as defined through billing items. The 574 billing items that resulted from a Premier billing chargemaster search for the term “drain” was further narrowed down to a list of 55 items by 2 clinicians separately. The outcomes for this study were the length of stay, cost of hospitalization, need for blood transfusion, and 90-day readmission, each chosen because of their associations with drain use in previous studies. The cost was adjusted for inflation and reported in 2016 US dollars.

For our 2 cohorts, we also obtained variables related to patient demographics, the health care system, the procedure, and comorbidities. Patient demographic variables included patient age, sex, and race (White, Black, other). Health care–related variables were insurance type (commercial, Medicaid, Medicare, Uninsured, and other), hospital location (rural, urban), hospital size (<300, 300-499, ≥500 beds), teaching status, and the annual number of ankle procedures performed per hospital. Procedure-related variables were the year, diagnosis of osteoarthritis, surgeon specialty (orthopaedic foot/ankle surgeon, podiatrist, other/missing), and use of a peripheral nerve block. Comorbidity variables were the Charlson-Deyo Index, history of smoking, and obesity documentation.21

Statistical Analysis

Analyses were stratified by surgical categories: TAA and ankle arthrodesis. Univariable associations between drain use, the aforementioned study variables, and outcomes were assessed using standardized differences. Because of the large sample size, univariable group differences are likely to reach statistical significance, so standardized mean differences were used. A standardized mean difference of 0.1 (or 10%) was considered to be a meaningful and significant difference in covariate distribution between groups.1

In our multivariable analysis, mixed effects models account for the correlation of care within hospitals and measure the association between drain use and the outcomes.28 The models were adjusted using the above covariates. Odds ratios or percentage change for continuous outcomes with 95% CIs were reported, and P values <.05 were considered significant. Continuous outcomes used a model with a gamma distribution and a log link function to account for the highly skewed nature of the variable.17,22 The multivariable analyses were performed using PROC GLIMMIX, and all analyses were done using SAS, version 9.4, statistical software (SAS Institute, Cary, NC).

Results

Trends Analysis

In our arthroplasty cohort, our analysis shows that a higher percentage of arthroplasties used drains from 2006 to 2010 when compared to 2011-2016 (standardized mean difference [SMD] = 0.8009). This trend was similar in arthrodesis cases, where a higher percentage of drains were placed between 2006 and 2012 when compared to 2013-2016 (SMD=0.3361) (Figure 2).
Arthroplasty Baseline Characteristics and Outcomes

In our study, a total of 4,977 patients underwent total ankle arthroplasty, and drains were used in 15% of cases (n=755). Comparing across groups with and without drains placed, there were no significant differences in patient age, gender, race, hospital location, and osteoarthritis history. In our study, however, fewer patients with increased comorbidities received drains (SMD=0.1321). Particularly, smoking was a comorbidity associated with reduced drain placement (SMD=0.2954), while obesity was not. Our study also shows drain use differences associated with insurance status (SMD=0.1390), hospital size (SMD=0.5971), hospital teaching status (SMD=0.1096), hospital procedure volume (SMD=0.6807), and surgeon specialty (SMD=0.9581) (Table 1).

In our univariable analyses, drains were associated with a reduced cost of hospitalization (SMD=0.1712). Our other outcomes of interest, however, did not reach statistical significance in this analysis. In our multivariable analyses, this significance in cost did not persist, as none of our outcomes reached statistical significance (all P > .05) (Table 3).

Arthrodesis Baseline Characteristics and Outcomes

In our study, a total of 10,085 patients underwent ankle arthrodesis, and drains were used in 11% (n=1074) of cases. Comparing groups with and without drains after arthrodesis, there were no significant differences in patient age, gender, race, hospital location, and osteoarthritis history. Similar to our findings in arthroplasty cases, our study shows differences in drain usage associated with insurance (SMD=0.1129), hospital size (SMD=0.4899), teaching hospital status (SMD=0.3536), and surgeon specialty (SMD=0.1866) (Table 2). Unlike our findings in arthroplasties, we found no associations between drain placement and total comorbidities, smoking, or obesity.

In our univariable analyses, there were no significant associations with our outcomes of interest. Our multivariable analyses where we account for various variables, however, showed increased blood transfusions (1.4, 95% CI 1.1, 1.8, P = .0168), length of stay (4.4%, 95% CI 0.6%, 8.4%, P = .0477), and cost of hospitalization (3.7%, 95% CI 0.0%, 7.5%, P = .0225) associated with drains (Table 3).

Discussion

This is the first national database study to assess patterns of drain use and outcomes in ankle arthroplasty and arthrodesis. Since 1961 when drains were first proposed in orthopaedic surgery for their surgical benefits, data assessing outcomes have made drain use increasingly controversial.26 Our study contributes to this discussion, with our findings suggesting that drains should not be used routinely in TAA and ankle arthrodesis.

In our first study objective, we found that drain use in arthrodesis and TAA reduced from 14% to 6% and 24% to 7% over our study period, respectively. This trend may be attributed to both advancements in surgery and the growth of literature surrounding drain use. Although extensively studied in other orthopaedic procedures, there lacks a consensus regarding drain use in ankle surgery.12,23 Over the span of our study, tranexamic acid (TXA) became more popular in orthopaedic surgery, reducing the theoretical need for drains because of its ability to decrease blood loss and the risk of blood transfusion. Furthermore, more and more studies in the orthopaedic literature, particularly in primary hip and knee arthroplasty, suggest that drains provide minimal added benefit.6,24,25 Broadly, these studies suggest that drain use generates no significant differences in infection risk, wound hematoma risk, joint function, clinical outcomes, transfusion rates, length of stay, or range of motion.2,6,26

The association of drains with an increased odds of blood transfusion in ankle arthrodesis (odds ratio = 1.4, P = .0168) is a significant finding in our study and is an association that has been documented in the lower extremity joint literature.11 Other arthroplasty studies have noted this trend as well, attributing the increased blood loss to the conduit provided from drains.2,6,29 Increased transfusions pose a clinical risk because of associated sequelae, including increased LOS, hemolytic transfusion reactions, pathogen transmission, immunologic reactions, transfusion-induced coagulopathy, renal failure, and death.27 Our results allow for a robust assessment of transfusion rates on a national level with more than 10,000 arthrodesis cases, whereas smaller studies may limit the power to detect differences in transfusion rates. Although our study is unable to delineate between open and laparoscopic arthrodesis cases, the association between drain use and transfusions persisted in several sensitivity analyses.

Our study also found associations between drains and increased LOS (4.4%, P = .0477) and cost of hospitalization (3.7%, P = .0225) in ankle arthrodesis, but no associations in TAA. In a study by Jiang et al11 comparing outcomes of arthrodesis and TAA, the authors found no difference in the LOS after each surgery, but an increased cost associated with TAA. By incorporating the variable of drain use, however, we found increases in these variables associated with arthrodesis. Although our study does not account for variations in each surgery, for example, cases that require flaps for closure, we believe that these differences are overcome by our large study sample size. Although the cost difference of drain use appears to be marginal, over 10 weeks in a single hospital, drain use has been associated with a total cost
Table 1. Total Ankle Arthroplasty Univariable Analyses.

| Patient demographics | Drain Used (n=755) | No Drain Use (n=4222) | Standardized Difference |
|----------------------|-------------------|-----------------------|-------------------------|
|                       | n | % or IQR       | n | % or IQR       |               |
| Age                  | 65 | 56-71         | 65 | 57-71         | 0.0458       |
| Gender               | 0.0777            |                        |                          |
| Female               | 397 | 52.6         | 2093 | 49.6         |               |
| Male                 | 358 | 47.4         | 2129 | 50.4         |               |
| Race                 | 0.0489            |                        |                          |
| White                | 655 | 86.8         | 3630 | 86.0         |               |
| Black                | 27 | 3.6          | 130 | 3.1          |               |
| Other                | 73 | 9.7          | 462 | 10.9         |               |
| Health care related  | 0.1390            |                        |                          |
| Insurance type       |                |                        |                          |
| Commercial           | 290 | 38.4        | 1599 | 37.9        |               |
| Medicaid             | 10 | 1.3          | 141 | 3.3          |               |
| Medicare             | 411 | 54.4        | 2242 | 53.1        |               |
| Uninsured            | 2 | 0.3          | 20 | 0.5          |               |
| Other                | 42 | 5.6          | 220 | 5.2          |               |
| Hospital location    | 0.0111            |                        |                          |
| Rural                | 9 | 1.2          | 204 | 4.8          |               |
| Urban                | 746 | 98.8        | 4018 | 95.2        |               |
| Hospital size        | 0.5971            |                        |                          |
| Small (<300 beds)    | 161 | 21.3        | 1757 | 41.6        |               |
| Medium (300-499 beds)| 356 | 47.2        | 915 | 21.7        |               |
| Large (≥500 beds)    | 238 | 31.5        | 1550 | 36.7        |               |
| Hospital teaching status | 0.1096     |                        |                          |
| Nonteaching          | 393 | 52.1        | 2077 | 49.2        |               |
| Teaching             | 362 | 48.0        | 2145 | 50.8        |               |
| Annual no. of procedures per hospital | 0.6807      |                        |                          |
| Procedure related    | 0.8009            |                        |                          |
| Year of procedure    |                |                        |                          |
| 2006                 | 11 | 14.7         | 64 | 85.3         |               |
| 2007                 | 42 | 23.6         | 136 | 76.4         |               |
| 2008                 | 95 | 36.5         | 165 | 63.5         |               |
| 2009                 | 106 | 31.5        | 231 | 68.5         |               |
| 2010                 | 155 | 35.2        | 285 | 64.8         |               |
| 2011                 | 46 | 11.3         | 362 | 88.7         |               |
| 2012                 | 79 | 14.0         | 487 | 86.0         |               |
| 2013                 | 57 | 10.0         | 512 | 90.0         |               |
| 2014                 | 69 | 10.6         | 585 | 89.4         |               |
| 2015                 | 45 | 5.9          | 720 | 94.1         |               |
| 2016                 | 50 | 6.9          | 675 | 93.1         |               |
| Osteoarthritis       | 211 | 27.9        | 1137 | 72.1        |               |
| Surgeon specialty    | 0.9581            |                        |                          |
| Orthopedics          | 281 | 37.2        | 3093 | 62.8        |               |
| Podiatry             | 91 | 12.1         | 654 | 87.9         |               |
| Other                | 383 | 50.7        | 475 | 49.3         |               |
| Comorbidity related  | 0.1321            |                        |                          |
| Charlson-Deyo Comorbidity Index (categorized) |        |                          |                          |
| 0                    | 510 | 67.5        | 2696 | 62.9        |               |
| 1                    | 182 | 24.1        | 1017 | 75.9        |               |
| 2                    | 45 | 6.0          | 331 | 94.0         |               |
| 2+                   | 18 | 2.4          | 178 | 97.6         |               |
| Smoking              | 102 | 13.5        | 1057 | 86.5        |               |
| Obesity              | 114 | 15.1        | 621 | 84.9         |               |
(continued)
### Table 1. (continued)

| Outcomes                        | Drain Used (n=755) | No Drain Use (n=4222) | Standardized Difference |
|---------------------------------|--------------------|-----------------------|-------------------------|
|                                  | n                  | % or IQR              | n                      | % or IQR              |                                      |
| Length of stay                  | 2                  | 1.3                   | 2                      | 1.3                   | 0.0245                                |
| Cost of hospitalization          | $20520 ($16457, $26275) | $21,672 ($17693, $27059) | 0.1712                  |
| Blood transfusion                | 13                 | 1.72                  | 59                     | 1.40                  | 0.0262                                |
| 90-d readmission                | 21                 | 2.78                  | 87                     | 2.06                  | 0.0469                                |

Abbreviation: IQR, interquartile range.

*Continuous variables median and IQR reported, instead of n and % respectively.*

### Table 2. Ankle Arthrodesis Univariable Analyses.

| Patient demographics            | Drain Used (n=1074) | No Drain Use (n=9011) | Standardized Difference |
|---------------------------------|--------------------|-----------------------|-------------------------|
|                                  | n                  | % or IQR              | n                      | % or IQR              |                                      |
| Age                             | 58                 | 48-67                 | 58                     | 48-67                 | 0.0083                                |
| Gender                          |                    |                       |                         |                       | 0.0680                                |
| Female                          | 485                | 45.2                  | 4524                   | 50.2                  |                                      |
| Male                            | 589                | 54.8                  | 4487                   | 49.8                  |                                      |
| Race                            |                    |                       |                         |                       | 0.0845                                |
| White                           | 851                | 79.2                  | 6861                   | 76.1                  |                                      |
| Black                           | 85                 | 7.9                   | 732                    | 8.1                   |                                      |
| Other                           | 138                | 12.8                  | 1418                   | 15.7                  |                                      |
| Health care related             |                    |                       |                         |                       | 0.1129                                |
| Insurance type                  |                    |                       |                         |                       |                                      |
| Commercial                      | 440                | 41.0                  | 3457                   | 38.4                  |                                      |
| Medicaid                        | 66                 | 6.1                   | 809                    | 9.0                   |                                      |
| Medicare                        | 461                | 42.9                  | 3900                   | 43.33                 |                                      |
| Uninsured                       | 19                 | 1.8                   | 147                    | 1.6                   |                                      |
| Other                           | 88                 | 8.2                   | 698                    | 7.7                   |                                      |
| Hospital location               |                    |                       |                         |                       | 0.0533                                |
| Rural                           | 78                 | 7.3                   | 420                    | 4.7                   |                                      |
| Urban                           | 996                | 92.7                  | 8591                   | 95.4                  |                                      |
| Hospital size                   |                    |                       |                         |                       | 0.4899                                |
| Small (<300 beds)               | 265                | 24.7                  | 2880                   | 32.0                  |                                      |
| Medium (300-499 beds)           | 592                | 55.1                  | 2901                   | 32.2                  |                                      |
| Large (≥500 beds)               | 217                | 20.2                  | 3230                   | 35.8                  |                                      |
| Hospital teaching status        |                    |                       |                         |                       | 0.3536                                |
| Nonteaching                     | 513                | 47.8                  | 4193                   | 46.5                  |                                      |
| Teaching                        | 561                | 52.2                  | 4818                   | 53.5                  |                                      |
| Annual no. of procedures per hospital | 16         | 14-18                  | 16                     | 14-20                 | 0.2221                                |
| Procedure related               |                    |                       |                         |                       | 0.3361                                |
| Year of Procedure               |                    |                       |                         |                       |                                      |
| 2006                            | 149                | 14.0                  | 912                    | 86.0                  |                                      |
| 2007                            | 153                | 15.2                  | 854                    | 84.8                  |                                      |
| 2008                            | 133                | 14.2                  | 802                    | 85.8                  |                                      |
| 2009                            | 116                | 11.3                  | 914                    | 88.7                  |                                      |
| 2010                            | 101                | 9.9                   | 922                    | 90.1                  |                                      |
| 2011                            | 91                 | 9.2                   | 894                    | 90.8                  |                                      |

(continued)
Table 2. (continued)

| Drain Used (n=1074) | No Drain Use (n=9011) | Standardized Difference |
|---------------------|-----------------------|-------------------------|
|                     | n         | % or IQR                  | n         | % or IQR                  |                  |
| 2012                | 119       | 11.9                      | 879       | 88.1                      |                  |
| 2013                | 75        | 8.8                       | 775       | 91.2                      |                  |
| 2014                | 58        | 7.1                       | 760       | 92.9                      |                  |
| 2015                | 41        | 5.6                       | 685       | 94.4                      |                  |
| 2016                | 38        | 5.8                       | 614       | 94.2                      |                  |
| Osteoarthritis      | 270       | 25.1                      | 2004      | 22.2                      | 0.0683           |
| Surgeon specialty   |           |                           |           |                           | 0.1866           |
| Orthopedics         | 574       | 53.4                      | 5566      | 61.8                      |                  |
| Podiatry            | 137       | 12.8                      | 1136      | 12.6                      |                  |
| Other               | 363       | 33.8                      | 2309      | 25.6                      |                  |
| Comorbidity related |           |                           |           |                           |                  |
| Charlson-Deyo       |           |                           |           |                           | 0.0783           |
| Comorbidity Index   |           |                           |           |                           |                  |
| (categorized)       |           |                           |           |                           |                  |
| 0                   | 560       | 52.1                      | 4510      | 50.0                      |                  |
| 1                   | 260       | 24.2                      | 2076      | 23.0                      |                  |
| 2                   | 114       | 10.6                      | 1141      | 12.7                      |                  |
| 2+                  | 140       | 13.0                      | 1284      | 14.2                      |                  |
| Smoking             | 286       | 26.6                      | 2482      | 27.5                      | 0.0206           |
| Obesity             | 243       | 22.6                      | 1916      | 21.2                      | 0.0683           |

Outcomes

| Length of stay       | 3         | 2.3                       | 2         | 1.3                       | 0.0576           |
| Cost of hospitalization$^a$ | $13858$     | $(9602, 20369)$           | $13055$   | $(8973, 19640)$           | 0.0149           |
| Blood transfusion    | 88        | 8.2                       | 554       | 6.1                       | 0.0793           |
| 90-d readmission     | 21        | 2.0                       | 184       | 2.0                       | 0.0062           |

Abbreviation: IQR, interquartile range.

$^a$Continuous variables median and IQR reported, instead of n and % respectively.

Table 3. Multivariable Analyses of Outcomes.$^a$

| Resource Utilization | Odds Ratio or % Change | P Value |
|----------------------|------------------------|---------|
| Total ankle arthroplasty |                        |         |
| Use of drains (reference = none) |                      |         |
| Length of stay         | 4.5% (–0.4%, 9.6%)     | .0723   |
| Cost of hospitalization | –1.2% (–4.6%, 2.4%) | .5138   |
| Blood transfusion       | 1.6 (0.7, 3.5)        | .2351   |
| Ankle arthrodesis |                        |         |
| Use of drains (reference = none) |                      |         |
| Length of stay         | 4.4% (0.6%, 8.4%)$^*$   | .0477   |
| Cost of hospitalization | 3.7% (0.0%, 7.5%)$^*$  | .0225   |
| Blood transfusion       | 1.4 (1.1, 1.8)$^*$     | .0168   |
| 90-d readmission        | 0.8 (0.5, 1.4)        | .4779   |

$^a$Model is adjusted for age, gender, race, insurance type, hospital location, bed size, teaching status, annual volume of procedures, year of procedure, osteoarthritis, surgeon specialty, Charlson-Deyo Comorbidity Index, smoking, obesity, and interaction term with procedure type and use of a peripheral never block.

$^*$P < .05.

of up to $432972\textsuperscript{10}$ Although there were statistically significant associations with arthrodesis, we found no statistically or clinically significant associations between our outcomes of interest and TAA drain use in our analysis. The absence of findings, however, supports findings in the knee arthroplasty literature of there being no associations between drains and
30-day readmissions. Although not a direct outcome of interest in our study, a recent assessment of 180 TAAs found that drains were associated with increased complications during the first 2 weeks postoperatively. If present in our large-scale study, however, this outcome would likely be present in our outcomes through increased costs, length of stay, and readmission.

There are several limitations to our study that should be recognized. First, this study is retrospective in nature, using observational claims data, so confounding variables such as operative time, preoperative hemoglobin, and postoperative drain protocols were unable to be assessed. We are also unable to verify the reliability of drain billing, which may lead to an underestimation of drains. Moreover, we cannot rule out reverse causation in which patients who are more likely to bleed are more likely to receive drains. However, we expect this to be unlikely because our findings were corroborated in several sensitivity analyses adjusting for observed and unobserved confounding. Additionally, our results suggest that hospital factors, not patient factors, are more important determinants of drain use, further minimizing the role of any reverse causation. Second, while Premier does not represent all hospitals in the United States (20%-25% of all hospitalizations), we believe that findings are generalizable as hospitals from all regions are included. Also, given the robustness of results, we do not expect outcomes to be substantially different in hospitals not included in Premier. Third, our database only draws from inpatient data, and we were only able to track readmissions of patients readmitted to the hospital where the primary surgical procedure took place. This may lead to an underestimation of readmission; however, this should be independent of drain use and is not likely to affect relative effects (ie, odds ratios), thus minimizing the role of this bias in the current study. Fourth, a portion of this study focuses on transfusion rates, and transfusion protocols vary between hospitals. Given that mixed effects models adjust for unspecified hospital-level effects, we expect that some of these adjustments will account for hospital-level protocols, thus minimizing this limitation. Lastly, considerations must be made that database studies can only report on associations and not causation. Therefore, sensitivity analyses were applied to confirm the robustness of results as the risk of confounding is ever-present in observational data.

In conclusion, in this national database study on drain use in ankle surgery, we found a decreasing trend in drain use over 10 years. In ankle arthrodesis, drain use was associated with higher odds for blood transfusion, costs, and LOS. These associations, however, were not found in TAA. Our study suggests that drains should not be used routinely, but future studies are required to discern the drivers of drain use in this distinct surgical population.

Ethical Approval

Ethical approval for this study was waived by the Mount Sinai Hospital Institutional Review Board because this study uses HIPAA-compliant anonymized data (project no. 14-00647).

Declaration of Conflicting Interests

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