

Ankle Fracture and Length of Stay in US Adult Population Using Data From the National COVID Cohort Collaborative

Charles C. Pitts, MD¹, Eli B. Levitt, MS^{1,2}, David A. Patch, MD¹, Alexander K. Mihas, BS^{1,2}, Alfredo Terrero, MD^{2,3}, Melissa A. Haendel, PhD⁴, Christopher G. Chute, MD⁵, Brent A. Ponce, MD⁶, Steven M. Theiss, MD¹, Clay A. Spitler, MD¹, and Michael D. Johnson, MD¹

Abstract

Background: The National COVID Cohort Collaborative (N3C) is an innovative approach to integrate real-world clinical observations into a harmonized database during the time of the COVID-19 pandemic when clinical research on ankle fracture surgery is otherwise mostly limited to expert opinion and research letters. The purpose of this manuscript is to introduce the largest cohort of US ankle fracture surgery patients to date with a comparison between lab-confirmed COVID-19–positive and COVID-19–negative.

Methods: A retrospective cohort of adults with ankle fracture surgery using data from the N3C database with patients undergoing surgery between March 2020 and June 2021. The database is an NIH-funded platform through which the harmonized clinical data from 46 sites is stored. Patient characteristics included body mass index, Charlson Comorbidity Index, and smoking status. Outcomes included 30-day mortality, overall mortality, surgical site infection (SSI), deep SSI, acute kidney injury, pulmonary embolism, deep vein thrombosis, sepsis, time to surgery, and length of stay. COVID-19–positive patients were compared to COVID-19–negative controls to investigate perioperative outcomes during the pandemic.

Results: A total population of 8.4 million patient records was queried, identifying 4735 adults with ankle fracture surgery. The COVID-19–positive group (n=158, 3.3%) had significantly longer times to surgery (6.5 ± 6.6 vs 5.1 ± 5.5 days, $P = .001$) and longer lengths of stay (8.3 ± 23.5 vs 4.3 ± 7.4 days, $P < .001$), compared to the COVID-19–negative group. The COVID-19–positive group also had a higher rate of 30-day mortality.

Conclusion: Patients with ankle fracture surgery had longer time to surgery and prolonged hospitalizations in COVID-19–positive patients compared to those who tested negative (average delay was about 1 day and increased length of hospitalization was about 4 days). Few perioperative events were observed in either group. Overall, the risks associated with COVID-19 were measurable but not substantial.

Level of Evidence: Level III, retrospective cohort study.

Keywords: Ankle fracture, SARS-CoV-2, COVID-19, Outcomes, Length of stay

Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and associated COVID-19 pandemic had substantial effects on orthopaedic surgery practices worldwide since the World Health Organization declared the pandemic in March 2020.^{7,11,19,20,31} However, the effects of

COVID-19 in patients with foot and ankle trauma was mostly limited to expert opinion and research letters.^{3,8,29} Over time, there has been an increase in elective case restrictions, delays in surgery, and changes in practices, which has warranted several investigations to assess management changes and outcomes associated with COVID-19



in patients undergoing ankle fracture surgery.^{13,23,27,30,32} Large-scale studies evaluating the trends of ankle fracture surgery during the pandemic are lacking.

Ankle fractures are among the most common surgically treated fractures.⁵ Compared to complications such as non-union, malunion, and implant failure, wound complications including surgical site infections remain the most frequently encountered.²⁴ Prior to the COVID-19 pandemic, established causative factors of wound complications included timing of surgery, incision placement, soft-tissue handling, fracture severity, and patient comorbidities such as smoking, obesity, and diabetes.²⁴ To our knowledge, the international foot and ankle community has yet to reach a consensus on the effects of COVID-19 on perioperative complications, mortality rates, and length of hospitalizations in ankle fracture surgery using a centralized data-driven approach. Thus, there is a need for large-scale, national-level investigation to assess surgical outcomes in adults undergoing ankle fracture surgery during the COVID-19 pandemic.

The National COVID Cohort Collaborative (N3C)¹⁰ was created to address many of the recognized challenges with the rapidly expanding number of COVID-19 publications.⁹ The N3C database is unique as it is a centralized national data enclave for studying COVID-19 and identifying potential management strategies as the pandemic continues to evolve. The N3C database integrates electronic health record (EHR) data on a secure enclave to support clinical discovery enabled by collaborative, large-scale, computationally intensive data science.¹⁰ Detailed protocols for EHR data integration with quality checks and rigorous analysis specifications are publicly available for review.¹⁸

Therefore, owing to the effects of COVID-19 in orthopaedic surgery patients but limited literature in operative ankle fractures, the purpose of this study was to investigate outcomes of the largest cohort of US adults undergoing ankle fracture surgery during the COVID-19 pandemic. We hypothesized that COVID-19–positive patients would have longer hospitalizations and increased complications compared to COVID-19–negative patients.

Methods

After obtaining IRB approval (IRB-300005866), we performed a retrospective cohort study of prospectively

collected data of COVID-19–tested patients using the N3C Data Enclave.¹⁰ Participants from March 15, 2020, to June 30, 2021, were grouped by lab-confirmed COVID-19 positive and negative via SARS-CoV-2 RT-PCR and Antigen testing. A COVID-19 positive group was created using a SARS-CoV-2 RT-PCR and Antigen–positive result. The COVID-19–negative group was identified using a SARS-CoV-2 RT-PCR and Antigen–negative result.

Study Cohort

Inclusion criteria included adults 18 years old or older with an inpatient hospital visit with a diagnostic test for COVID-19, a fracture, and surgical treatment for ankle fracture (CPT codes: 27766, 27769, 27792, 27814, 27822, 27823, 27829). Surgery had to occur 7 days before or up to 30 days after COVID-19 hospitalization.⁶

Variables

The primary independent variable in this study was COVID-19 status, as described above. Patient characteristics included age, gender, race, body mass index, smoking status, and the Charlson Comorbidity Index.²² Additional variables were selected the N3C cohort characterization,¹ and perioperative complications reported by the Centers for Medicare & Medicaid.² Outcomes included 30-day mortality, overall mortality, surgical site infection (SSI), deep SSI, acute kidney injury, invasive ventilation, pulmonary embolism, deep vein thrombosis, sepsis, time to surgery (days), and length of stay (days). Additional definitions, details, and computer programming code for the validated variables used for the study are available online at Github.¹⁷ In order to be included in the analysis, the data were processed and evaluated with input from informatics and clinical subject matter experts.¹

Statistical Analysis

The analyses were conducted with data and tools accessed through the NCATS N3C Data Enclave.¹⁰ Row-level patient information was not downloaded from the secure Data Enclave to protect the confidentiality of the study participants.

¹Department of Orthopaedic Surgery, University of Alabama at Birmingham, Birmingham, AL, USA

²Department of Translational Medicine, Florida International University Herbert Wertheim College of Medicine, Miami, FL, USA

³Department of Translational Medicine, University of Miami Miller School of Medicine, Miami, FL, USA

⁴Center for Health AI, University of Colorado Anschutz Medical Campus, Aurora, CO, USA

⁵Schools of Medicine, Public Health, and Nursing, Johns Hopkins University, Baltimore, MD, USA

⁶Hughston Clinic, Columbus, GA, USA

Corresponding Author:

Michael D. Johnson, MD, Department of Orthopaedic Surgery, University of Alabama at Birmingham, 1313 13th St S, Floor 2, Birmingham, AL 35205, USA.

Email: michaeljohnson@uabmc.edu

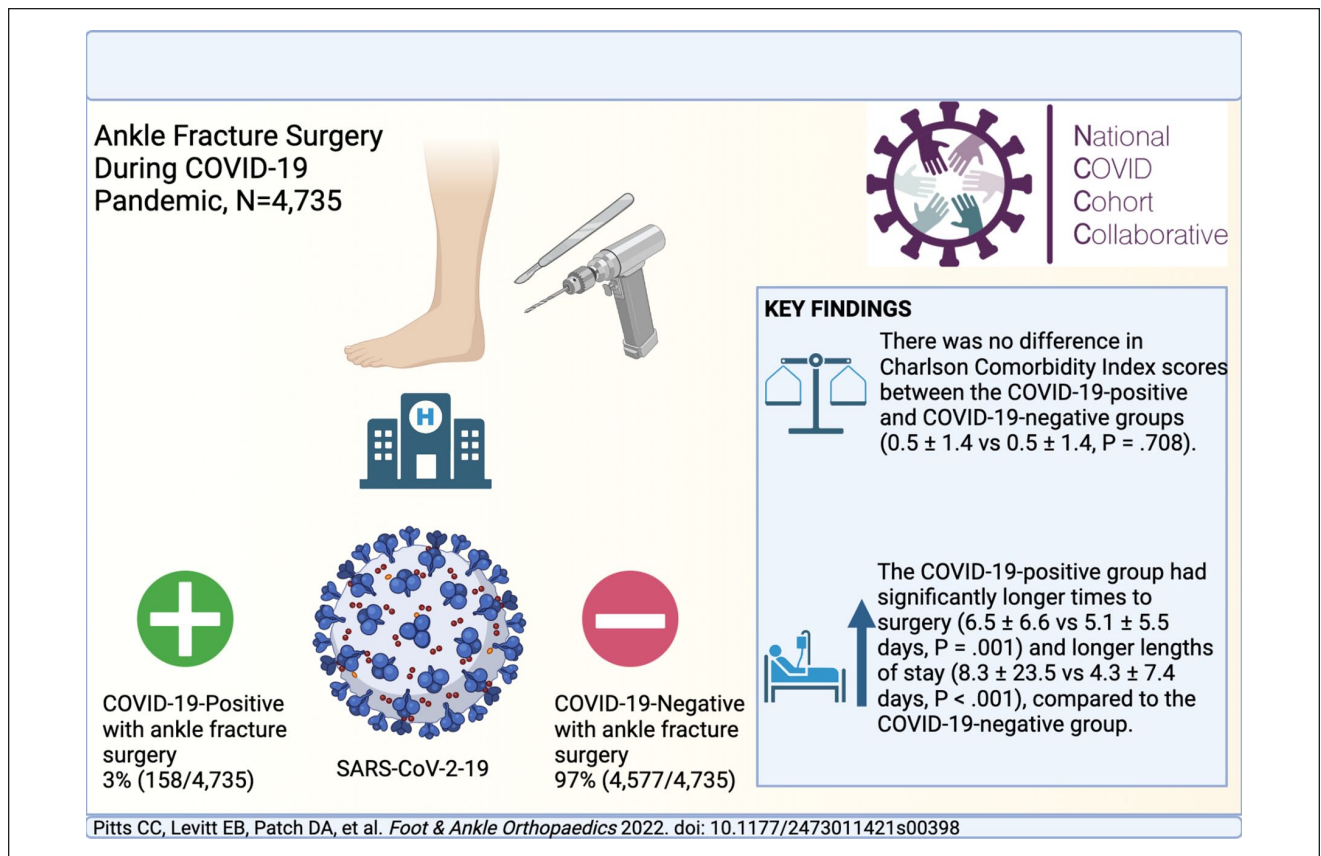


Figure 1. Ankle fractures in US adult population using data from National COVID Cohort Collaborative. Created with BioRender.com.

Descriptive statistics were performed for baseline characteristics and perioperative complications. Categorical variables were described as percentages, and continuous variables were described as mean \pm SD. Chi-square tests and Fisher exact tests were used to compare categorical variables, and independent samples *t* tests were used to compare continuous variables. *P* values of $<.05$ were considered statistically significant. Consistent with N3C publication principles, values between 1 and 20 were reported as ≤ 20 .¹⁷

Results

Baseline Characteristics

The total population queried consisted of 8.4 million patients, with 4735 patients meeting inclusion criteria for the study (Figure 1). The baseline characteristics of this cohort are shown in Table 1. The COVID-19-positive group included 158 patients (3.3%), which had a mean age of 46.6 ± 18.7 years and consisted of 89 (56.3%) females. These patients were compared with 4577 COVID-19-negative patients. This group had a mean age of 47.0 ± 17.7 years and consisted of 2437 (53.2%) females. The 2

groups differed in terms of smoking status, where the COVID-19-positive group had a significantly lower proportion of current or former smokers compared with the COVID-19-negative group (27.8 vs 38.1%, $P = .012$). The groups had comparable body mass indexes (32.0 ± 9.0 vs 30.6 ± 7.4 , $P = .097$). There was no difference in comorbidity burden as measured by the Charlson Comorbidity Index scores between the COVID-19-positive and COVID-19-negative groups (0.5 ± 1.4 vs 0.5 ± 1.4 , $P = .708$).

Perioperative Outcomes

The COVID-19-positive group had significantly longer times to surgery (6.5 ± 6.6 vs 5.1 ± 5.5 days, $P = .001$) and longer lengths of stay (8.3 ± 23.5 vs 4.3 ± 7.4 days, $P < .001$) compared to the COVID-19-negative group. Furthermore, the COVID-19-positive group had significantly higher rates of 30-day mortality, with $n \leq 20$ for both groups ($P = .033$), as well as higher rates of deep SSI ($P = .022$). The COVID-19-positive group also had a higher rate of deep vein thrombosis compared to controls, but this difference did not reach statistical significance ($P = .077$) (Table 2). In contrast, the COVID-19-negative group had a higher rate of pulmonary embolism ($n \leq 20$). There were no

Table 1. Baseline Characteristics in Adults Undergoing Ankle Fracture Surgery From the National COVID Cohort Collaborative.

	COVID-19–Positive (n=158)	COVID-19–Negative (n=4577)	P Value
Age, y, mean \pm SD	46.6 \pm 18.7	47.0 \pm 17.7	.789
Gender, n (%)			.495
Female	89 (56.3)	2437 (53.2)	
Male	59 (43.7)	2140 (46.8)	
Race, n (%)			.600
Asian	$\leq 20^{a,b}$	60 (1.3)	
Black or African American	23 (14.6)	725 (15.8)	
White	105 (66.5)	3207 (70.1)	
Other	$\leq 20^b$	26 (0.6)	
Not reported	0	559 (12.2)	
Body mass index, mean \pm SD	32.0 \pm 9.0	30.6 \pm 7.4	.097
Smoking status, n (%)			.012
Current or former	44 (27.8)	1742 (38.1)	
Nonsmoker	114 (72.2)	2835 (61.9)	
Charlson Comorbidity Index, mean \pm SD	0.5 \pm 1.4	0.5 \pm 1.4	.708

^aIn accordance with N3C publication principles, values 1-20 are reported as ≤ 20 .

^bPercentage is lower compared with the control group.

Table 2. Perioperative Outcomes in Adults Undergoing Ankle Fracture Surgery From the National COVID Cohort Collaborative.^a

	COVID-19–Positive (n=158)	COVID-19–Negative (n=4577)	P Value
Time to surgery, d, mean \pm SD	6.5 \pm 6.6	5.1 \pm 5.5	.001
Length of stay, d, mean \pm SD	8.3 \pm 23.5	4.3 \pm 7.4	<.001
SSI	$\leq 20^{b,c}$	57 (1.2)	.719
Deep SSI	$\leq 20^c$	≤ 20	.022
Acute kidney injury	$\leq 20^c$	142 (3.1)	.111
Invasive ventilation	$\leq 20^c$	125 (2.7)	.134
Pulmonary embolism	0 (0.0)	≤ 20	.009
Deep vein thrombosis	$\leq 20^c$	56 (1.2)	.077
Sepsis	$\leq 20^c$	67 (1.5)	.912
30-d mortality	$\leq 20^c$	≤ 20	.033
Overall mortality	$\leq 20^c$	57 (1.2)	.719

^aUnless otherwise noted, values are n (%).

^bIn accordance with N3C publication principles, values 1-20 are reported as ≤ 20 .

^cPercentage is higher compared with the control group.

statistically significant differences for SSI, acute kidney injury, invasive ventilation, sepsis, or overall mortality between the 2 groups. Frequency of perioperative complications in COVID-19–positive and COVID-19–negative patients can be found in Table 2.

Discussion

The COVID-19 pandemic has placed tremendous strain on the healthcare system and healthcare workers worldwide. In addition to its tragic effects of cardiopulmonary morbidity and mortality, COVID-19 has affected the operative management of many conditions, including musculoskeletal injuries, leading to reductions in elective surgeries and changes in

perioperative protocols.^{4,14,25} Moreover, recent guidelines developed by the International Consensus Group recommend that patients with COVID-19 should avoid undergoing elective orthopaedic procedures.²¹ Because ankle fractures are one of the most common surgically treated injuries in orthopaedics, with one study showing that they can constitute up to 17% of fractures among hospitalized trauma patients, we believed it was imperative to assess outcomes in these patients during the pandemic.^{5,26} Furthermore, rotational ankle fractures represent an injury that continues to increase in incidence with the growth of the geriatric population.²⁸ Thus, the goal of our study was to investigate outcomes in adults undergoing ankle fracture surgery during the COVID-19 pandemic using a centralized US national data enclave.

Our results show that COVID-19–positive patients admitted with ankle fractures length of stay was 4 days greater than those who tested negative (8.3 vs 4.3 days). In a 2012 study, the mean length of hospital stay (LOS) for closed ankle fractures was 6.6 days, which decreased by an average 0.14 days with each subsequent year over the 15-year study period.²⁸ These findings complement the average 4.3-day LOS observed in the COVID-19–negative group in our cohort. Furthermore, along with the substantially increased cost associated with longer admissions,¹⁵ a prolonged hospital stay may affect recovery and rehabilitation following surgery, but future studies assessing this association during the COVID-19 pandemic are needed.

In addition to length of stay, our study showed that a concomitant COVID-19 diagnosis experienced longer delays until surgery by approximately 1 day and portended an increased risk of 30-day mortality, which are well-documented associations in operative patients with COVID-19 infection.⁶ The higher rate of 30-day mortality among COVID-19–positive patients is likely related to factors that were not assessed in the N3C database, such as pneumonia, acute respiratory distress syndrome, and cardiovascular complications.^{12,16} Interestingly, COVID-19–negative patients had a higher rate of pulmonary embolism, with none of the COVID-19–positive patients experiencing this complication. This may be explained by the fact that the COVID-19–negative group was substantially larger than the COVID-19–positive group. There were no significant differences in all-cause mortality, surgical site infections, invasive ventilation, deep vein thrombosis, acute kidney injury, or sepsis, between the 2 groups.

Although this study provides insight into the perioperative complications of patients who suffered ankle fractures during the COVID-19 pandemic, it is not without limitations. First, the large N3C database of patients receiving care across the United States allows access to sizable quantities of patients and data; however, it lacks long-term follow-up as well as variables important to the field of orthopaedic surgery, such as injury mechanisms, fracture classification, estimated blood loss, functional outcomes, radiographic healing, pain scores, and patient satisfaction. Second, we chose to focus on patients treated surgically as inpatients, so comparisons with those treated nonoperatively as well as those treated as outpatients was not performed in this analysis. Owing to privacy rules within the National COVID Cohort Collaborative, we were unable to precisely report the outcomes that were 20 or fewer, which leaves ambiguity in interpreting the data. Despite this limitation, this information at a national scale is helpful to understand the approximate risks of operative ankle fractures during the COVID-19 pandemic.

Using the N3C database, our study showed that COVID-19–positive patients with ankle fractures requiring surgery had longer delays until surgery and longer hospitalizations

compared with those who tested negative, with few perioperative events. Further research is needed as multiday increases in hospital stay may lead to delays in the recovery and rehabilitative process, as well as increased hospital costs. This study also demonstrated that COVID-19–positive patients experienced increased rates of 30-day mortality. Overall, the results do not suggest that patients with operative ankle fractures were at a substantially increased risk during the COVID-19 pandemic. As the pandemic evolves and continues, future investigations should be aimed at further assessing the associations observed in this study as well as identifying ways to improve patient-reported and postoperative outcomes in ankle fracture patients. There is limited evidence to support delays in surgery in the context of testing for COVID-19. Surgeons can inform their patients that the overwhelming majority of patients tested for COVID-19 were negative at the time of ankle injury, and the risks associated with COVID-19 may be slightly elevated.

Acknowledgment

We gratefully acknowledge contributions from the following N3C core teams: Principal investigators: Melissa A. Haendel*, Christopher G. Chute*, Kenneth R. Gersing, and Anita Walden; Workstream, subgroup and administrative leaders: Melissa A. Haendel*, Tellen D. Bennett, Christopher G. Chute, David A. Eichmann, Justin Guinney, Warren A. Kibbe, Hongfang Liu, Philip R.O. Payne, Emily R. Pfaff, Peter N. Robinson, Joel H. Saltz, Heidi Spratt, Justin Starren, Christine Suver, Adam B. Wilcox, Andrew E. Williams, and Chunlei Wu; Key liaisons at data partner sites; Regulatory staff at data partner sites;

Individuals at the sites who are responsible for creating the datasets and submitting data to N3C; Data Ingest and Harmonization Team: Christopher G. Chute*, Emily R. Pfaff*, Davera Gabriel, Stephanie S. Hong, Kristin Kostka, Harold P. Lehmann, Richard A. Moffitt, Michele Morris, Matvey B. Palchuk, Xiaohan Tanner Zhang, and Richard L. Zhu.

Phenotype Team (individuals who create the scripts that the sites use to submit their data, based on the COVID and Long COVID definitions): Emily R. Pfaff*, Benjamin Amor, Mark M. Bissell, Marshall Clark, Andrew T. Girvin, Stephanie S. Hong, Kristin Kostka, Adam M. Lee, Robert T. Miller, Michele Morris, Matvey B. Palchuk, and Kellie M. Walters; Project Management and Operations Team: Anita Walden*, Yooree Chae, Connor Cook, Alexandra Dest, Racquel R. Dietz, Thomas Dillon, Patricia A. Francis, Rafael Fuentes, Alexis Graves, Julie A. McMurry, Andrew J. Neumann, Shawn T. O'Neil, Andréa M. Volz, and Elizabeth Zampino; Partners from NIH and other federal agencies: Christopher P. Austin*, Kenneth R. Gersing*, Samuel Bozzette, Mariam Deacy, Nicole Garbarini, Michael G. Kurilla, Sam G. Michael, Joni L. Rutter, and Meredith Temple-O'Connor; Analytics Team (Individuals who build the Enclave infrastructure, help create codesets, variables, and help Domain Teams and project teams with their datasets): Benjamin Amor*, Mark M. Bissell, Katie Rebecca Bradwell, Andrew T. Girvin, Amin Manna, Saad Ljzouli, and Nabeel Qureshi; Publication Committee Management Team:

Mary Morrison Saltz*, Christine Suver*, Christopher G. Chute, Melissa A. Haendel, Julie A. McMurry, Andréa M. Volz, Anita Walden, Mary Emmett, and Victor Garcia; Publication Committee Review Team: Carolyn Bramante, Jeremy Richard Harper, Wendy Hernandez, Farrukh M Koraiшы, Federico Mariona, Saidulu Mattapally, Amit Saha, and Satyanarayana Vedula.

*Members of the National COVID Cohort Collaborative (N3C).

Ethics Approval

Ethical approval for this study was obtained from the University of Alabama at Birmingham Institutional Review Board (IRB-300005866). The N3C data transfer to NCATS is performed under a Johns Hopkins University Reliance Protocol (IRB00249128) or individual site agreements with NIH. The N3C Data Enclave is managed under the authority of the NIH; information can be found at <https://ncats.nih.gov/n3c/resources>.




Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. ICMJE forms for all authors are available online.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: US Department of Health and Human Services, National Institutes of Health, National Center for Advancing Translational Sciences (NCATS U24 TR002306, NCATS UL1 TR003096). The analyses described in this report were conducted with data or tools accessed through the NCATS N3C Data Enclave <https://covid.cd2h.org> and N3C Attribution & Publication Policy v 1.2-2020-08-25b supported by NCATS U24 TR002306 and NCATS UL1 TR003096. This research was possible because of the patients whose information is included within the data and the organizations (<https://ncats.nih.gov/n3c/resources/data-contribution/data-transfer-agreement-signatories>) and scientists who have contributed to the ongoing development of this community resource (<https://doi.org/10.1093/jamia/ocaa196/5893482>).

ORCID iDs

Eli B. Levitt, MS,  <https://orcid.org/0000-0002-3921-5653>
 Christopher G. Chute, MD,  <https://orcid.org/0000-0001-5437-2545>
 Michael D. Johnson, MD,  <https://orcid.org/0000-0002-3205-755X>

References

- Bennett TD, Moffitt RA, Hajagos JG, et al. Clinical characterization and prediction of clinical severity of SARS-CoV-2 infection among US adults using data from the US National COVID Cohort Collaborative. *JAMA Network Open*. 2021;4(7):e2116901. doi: 10.1001/jamanetworkopen.2021.16901
- Centers for Medicare & Medicaid Services. Hospital-Acquired Conditions. 2020.
- Chang SH. Foot and ankle surgery during the COVID-19 pandemic in Tokyo. *J Foot Ankle Surg*. 2020;59(5):888. doi: 10.1053/j.jfas.2020.06.014
- Coccolini F, Perrone G, Chiarugi M, et al. Surgery in COVID-19 patients: operational directives. *World J Emerg Surg*. 2020;15(1):25. doi: 10.1186/s13017-020-00307-2
- Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. *Injury*. 2006;37(8):691-697.
- COVIDSurg Collaborative. Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. *Lancet*. 2020;396(10243):27-38. doi: 10.1016/s0140-6736(20)31182-x
- Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Biomed*. 2020;91(1):157-160. doi: 10.23750/abm.v91i1.9397
- Day J, MacMahon A, Roberts MM, et al. Perspectives from the foot and ankle department at an academic orthopedic hospital during the surge phase of the COVID-19 pandemic in New York City. *Foot Ankle Int* 2020;41(7):881-884. doi: 10.1177/1071100720930003
- Gazendam A, Ekhtiari S, Wong E, et al. The “infodemic” of journal publication associated with the novel coronavirus disease. *J Bone Joint Surg Am*. 2020;102(13):e64(1-4). doi: 10.2106/JBJS.20.00610
- Haendel MA, Chute CG, Bennett TD, et al. The National COVID Cohort Collaborative (N3C): rationale, design, infrastructure, and deployment. *J Am Med Inform Assoc*. 2021;28(3):427-443. doi: 10.1093/jamia/ocaa196
- Levitt EB, Patch DA, Mabry S, et al. Association between COVID-19 and Mortality in Hip Fracture Surgery in the National COVID Cohort Collaborative (N3C). *J Am Acad Orthop Surg Glob Res Rev*. 2022;6(1):e21.00282. doi: 10.5435/JAAOSGlobal-D-21-00282
- Long B, Brady WJ, Koyfman A, Gottlieb M. Cardiovascular complications in COVID-19. *Am J Emerg Med*. 2020;38(7):1504-1507. doi: 10.1016/j.ajem.2020.04.048
- Manz WJ, Goel R, Fakunle OP, Labib SA, Bariteau JT. Feasibility of rapid development and deployment of a telemedicine program in a foot and ankle orthopedic practice. *Foot Ankle Int*. 2021;42(3):320-328. doi: 10.1177/1071100720963059
- Massey PA, McClary K, Zhang AS, Savoie FH, Barton RS. Orthopaedic surgical selection and inpatient paradigms during the coronavirus (COVID-19) pandemic. *J Am Acad Orthop Surg*. 2020;28(11):436-450. doi: 10.5435/JAAOS-D-20-00360
- Murray AM, McDonald SE, Archbold P, Crealey GE. Cost description of inpatient treatment for ankle fracture. *Injury*. 2011;42(11):1226-1229. doi: 10.1016/j.injury.2010.08.023
- Namendys-Silva SA. ECMO for ARDS due to COVID-19. *Heart Lung*. 2020;49(4):348-349. doi: 10.1016/j.hrtlng.2020.03.012
- National COVID Cohort Collaborative (N3C). N3C Consortium. Attribution and publication principles for N3C. 2021.
- National COVID Cohort Collaborative (N3C). Phenotype data acquisition, version 3.2. *GitHub*. GitHub; 2021.

19. Navarro RA, Reddy NC, Weiss JM, et al. Orthopaedic systems response to and return from the COVID-19 pandemic: lessons for future crisis management. *J Bone Joint Surg Am.* 2020;102(14):e75. doi: 10.2106/jbjs.20.00709
20. Oussedik S, Zagra L, Shin GY, D'Apolito R, Haddad FS. Reinstating elective orthopaedic surgery in the age of COVID-19. *Bone Joint J.* 2020;102-B(7):807-810. doi: 10.1302/0301-620X.102B7.BJJ-2020-0808
21. Parvizi J, Gehrke T, Krueger CA, et al. Resuming elective orthopaedic surgery during the COVID-19 pandemic: guidelines developed by the International Consensus Group (ICM). *J Bone Joint Surg Am.* 2020;102(14):1205-1212. doi: 10.2106/JBJS.20.00844
22. Quan H, Li B, Couris CM, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. *Am J Epidemiol.* 2011;173(6):676-682. doi: 10.1093/aje/kwq433
23. Regala P, White PB, Bitterman AD, Katsigiorgis G, Dicipinigitis PA. Delay in treatment of a bimalleolar ankle fracture during coronavirus disease-19 COVID-19 pandemic leading to amputation. *J Orthop Case Rep.* 2021;11(4):28-32. doi: 10.13107/jocr.2021.v11.i04.2138
24. Schepers T, De Vries MR, Van Lieshout EM, Van der Elst M. The timing of ankle fracture surgery and the effect on infectious complications; a case series and systematic review of the literature. *Int Orthop.* 2013;37(3):489-494. doi: 10.1007/s00264-012-1753-9
25. Service BC, Collins AP, Crespo A, et al. Medically necessary orthopaedic surgery during the COVID-19 pandemic: safe surgical practices and a classification to guide treatment. *J Bone Joint Surg Am.* 2020;102(14):e76. doi: 10.2106/JBJS.20.00599
26. Somersalo A, Paloneva J, Kautiainen H, Lonroos E, Heinanen M, Kiviranta I. Incidence of fractures requiring inpatient care. *Acta Orthop.* 2014;85(5):525-530. doi: 10.3109/17453674.2014.908340
27. Stringer H, Molloy A, Craven J, Moorehead J, Santini A, Mason L. The impact of COVID-19 on foot and ankle surgery in a major trauma centre. *Foot (Edinb).* 2021;46:101772. doi: 10.1016/j.foot.2020.101772
28. Thur CK, Edgren G, Jansson KA, Wretenberg P. Epidemiology of adult ankle fractures in Sweden between 1987 and 2004: a population-based study of 91,410 Swedish inpatients. *Acta Orthop.* 2012;83(3):276-281. doi: 10.3109/17453674.2012.672091
29. Vosoughi AR, Borazjani R. COVID-19 effect on foot & ankle surgery in Shiraz, South of Iran. *J Foot Ankle Surg.* 2020;59(5):887. doi: 10.1053/j.jfas.2020.06.013
30. White PB, Partan M, Iturriaga C, et al. Epidemiology and clinical outcomes of foot and ankle trauma during the first wave of the COVID-19 pandemic in the New York metropolitan area. *Orthopedics.* 2021;44(5):313-319. doi: 10.3928/01477447-20210819-01
31. Wong JSH, Cheung KMC. Impact of COVID-19 on orthopaedic and trauma service: an epidemiological study. *J Bone Joint Surg Am.* 2020;102(14):e80. doi: 10.2106/jbjs.20.00775
32. Yu P, Wu C, Zhuang C, et al. The patterns and management of fracture patients under COVID-19 outbreak in China. *Ann Transl Med.* 2020;8(15):932. doi: 10.21037/atm-20-4174