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Octogenarian and Nonagenarians Are at a Higher Risk for Experiencing Adverse 30-Day Outcomes Following ORIF of Ankle Fractures

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Abstract

Introduction: Despite an increasing number of elderly individuals undergoing surgical fixation for ankle fractures, few studies have investigated peri-operative outcomes and safety of surgery in an octogenarian and nonagenarian population (age >80 years). **Materials and Methods:** The 2012-2017 American College of Surgeons database was queried for patients undergoing open reduction internal fixation for isolated uni-malleolar, bi-malleolar and tri-malleolar ankle fractures. The study cohort was divided into 3 comparison groups (age <65 years, 65-75 and >80). Multi-variate regression analyzes were used to compare the independent effect of varying age groups on 30-day post-operative outcomes while controlling for baseline clinical characteristics and co-morbidity burdens. **Results:** A total of 19,585 patients were included: 5.3% were >80 years, 18.1% were 65-79 years, and 76.6% were <65 years. When compared to the non-geriatric population, individuals >80 years were at a significantly Abstract: higher risk of 30-day wound complications (OR 1.84; $p = 0.019$), pulmonary complications (OR 3.88; $p < 0.001$), renal complications (OR 1.96; $p = 0.015$), septic complications (OR 3.72; $p = 0.002$), urinary tract infections (OR 2.24; $p < 0.001$), bleeding requiring transfusion (OR 1.90; $p = 0.025$), mortality (OR 7.44; $p < 0.001$), readmissions (OR 1.65; $p = 0.004$) and non-home discharge (OR 13.91; $p < 0.001$). **Discussion:** Octogenarians undergoing ankle fracture fixation are a high-risk population in need of significant pre-operative surgical and medical optimization. With the majority of patients undergoing non-elective ORIF procedures, it is critical to anticipate potential complications and incorporate experienced geriatric providers early in the surgical management of these patients. **Conclusions:** Octogenarians and nonagenarians are fundamentally distinct and vulnerable age groups with a high risk of complications, readmissions, mortality and non-home discharges compared to other geriatric (65-79 years) and non-geriatric (<65 years) patients. Pre-operative counseling and risk-stratification are essential in this vulnerable patient population.

Keywords

geriatric trauma, octogenarian, ankle fracture, surgical outcomes, nonagenarian

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Introduction

Ankle fractures are the third most common orthopedic injury sustained in the elderly, behind hip and distal radius fractures, thus contributing to a significant economic burden in the geriatric population.[1,2] A large percentage of these fractures are the sequelae of falls, which lead to many non-elective surgical procedures.[3] Despite an increasing number of elderly individuals undergoing open reduction and internal fixation (ORIF) of ankle fractures, few studies have investigated peri-operative

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outcomes and safety of surgery in an octogenarian and nonagenarian population (age ≥80 years). Past literature has shown octogenarians to be a more vulnerable population, with greater rates of adverse outcomes and higher resource utilization across a variety of orthopedic procedures as compared to individuals <80 years.[4,5]

Octogenarian and nonagenarian patients require careful surgical consideration due to increased mortality risk and short-term surgical complications.[5-7]Age ≥80 has been documented as a risk factor for poor surgical outcomes following primary knee arthroplasty and total hip arthroplasty.[8,9] In ankle-specific studies, risk factors for poor outcomes in geriatric populations include pre-existing diabetes, obesity,[10] nursing home discharge,[11] operative time[12] and weight bearing restrictions.[13] Limited studies summarize the risks and outcomes for ankle fractures in the octogenarian and nonagenarian populations. Thus, this study aims to define these risks associated with co-morbidity burden, dependency status, discharge disposition, as well as to identify adverse outcomes following ORIF of ankle fractures in the octogenarians compared to a non-geriatric patient population.

Patients and Methods

This was a retrospective cohort study carried out using prospectively collected data from the American College of Surgeons—National Surgical Quality Improvement Program (ACS-NSQIP) database. The ACS-NSQIP is a comprehensive surgical outcomes database, that contains surgical data from over 600 hospitals across the United States. The data are recorded and stored in the database using a strict and regular audit process conducted by trained clinical reviewers. The specifics of data collection, risk adjustment, and accuracy measures have been outlined.[14] The 2012-2017 ACS-NSQIP database was queried using Current Procedural Terminology codes for patients undergoing open reduction internal fixation (ORIF) for isolated uni-malleolar (CPT-27766, CPT-27769, CPT-27792), bi-malleolar (CPT-27814) and tri-malleolar (CPT-27822,CPT-27823) ankle fractures. Polytrauma patients with concomitant lower extremity injuries were excluded.

The study cohort was divided into 3 distinct groups for comparisons (age <65 years, age 65-79 years and age≥ 80 years/octogenarians + nonagenarians). Screening for thirty-day complications included superficial and deep wound infections, pulmonary compromise, cardiac complications, thromboembolic events, sepsis, renal insufficiency, urinary tract infections, blood transfusions, mortality rate, re-operations, re-admissions and non-home discharges.

Pearson-Chi square tests were used to assess for significant differences in baseline demographics and procedural characteristics between the 3 age groups. Multi-variate logistic regression analyzes were used to assess for the impact of increasing age group on 30-day outcomes while controlling for baseline demographics and procedural characteristics (age, gender, sex, race, fracture type/severity, open vs. closed fracture, admission status, BMI, co-morbidities, functional health status, ASA group and operative time). For analytical purposes, age <65 years was utilized as the reference group. Results from regression models have been reported as adjusted odds ratio (OR) with their 95% confidence intervals and p-values. A p-value < 0.05 was considered significant. All statistical analyzes were performed using SPSSv24 (IBM, Armonk, NY).

Table 1. Baseline Demographics and Comorbidity Comparison of the Study Population Divided into 3 Age Ranges.

Demographics	(%) <65 years (n = 15,008)	(%) 65-79 years (n = 3,544)	(%) ≥80 years (n = 1,033)	P-value
Gender				
Female	55.3	71.8	78.4	<0.001
Race				
White	63.5	75.3	77.5	<0.001
Black or African-American	11.8	5.9	4.5	
Other	3.7	1.9	2.1	
Unknown	21	16.9	15.9	
BMI				
<25.0	20.1	16.7	26.5	<0.001
25.0-29.9	33.1	34.7	36.7	
30.0-34.9	23.9	27.3	22.1	
≥35.0	22.8	21.3	14.7	
Functional health status				
Independent	97.1	94.1	85.4	<0.001
Dependent	1.6	4.9	13.3	
Unknown	1.3	1	1.4	
Diabetes Mellitus				
Insulin-Dependent	3.3	11.6	9.4	<0.001
Non-insulin-dependent	4.6	13.8	15.1	
Pre-operative systemic sepsis				
Sepsis	0.1	0.1	0.3	<0.001
Septic shock	2.2	3.1	4.7	
Smoking	29.8	10.4	3.2	<0.001
Dyspnea	1.9	6	7.7	<0.001
Pre-operative ventilator dependence	<0.1	0.1	0.1	0.082
COPD	1.9	7.8	8.8	<0.001
Ascites	<0.1	0.2	0	<0.001
CHF	0.2	1.4	3.3	<0.001
Hypertension	21.9	64.1	77	<0.001
Acute renal failure	0.1	0.5	0.7	<0.001
Dialysis	0.5	1.2	1.5	<0.001
Disseminated Cancer	0.2	0.6	0.9	<0.001
Open wound/ fracture	2	3.5	7.7	<0.001
Chronic steroid use	1.3	3.5	3.7	<0.001
Weight loss <10% body weight in last 6 months	<0.1	0.2	0.2	<0.001
Bleeding disorders	1.6	7.1	12.4	<0.001
Pre-op transfusion	0.2	0.9	1.5	<0.001

Table 2. Operative and Procedural Factor Comparison of the Population Divided Into 3 Age Ranges.

Operative factors	(%) <65 years (n = 15,008)	(%) 65-79 years (n = 3,544)	(%) ≥80 years (n = 1,033)	P-value
Location of Surgery				**<0.001***
Inpatient	31.5	56.9	79	
Outpatient	68.5	43.1	21	
Type of fracture				**<0.001***
Uni-malleolar	41.3	24.8	21.2	
Bi-malleolar	34.4	42.4	52.1	
Tri-malleolar	24.3	32.8	26.7	
ASA Class >II	20	52.7	75.8	**<0.001***
Total operative time >90 mins	29.9	25.7	24.5	**<0.001***

Asterix indicates significance.

Table 3. Thirty-Day Outcomes Comparing the 3 Age Ranges Before Adjusting for Baseline Characteristics.

30-day outcomes	<65 years	65-79 years	≥80 years	P-value
Wound complications	166 (1.1%)	53 (1.5%)	24 (2.3%)	**0.001***
Pulmonary complications	28 (0.2%)	41 (1.2%)	29 (2.8%)	**<0.001***
Thromboembolic complications	69 (0.5%)	26 (0.7%)	4 (0.4%)	0.101
Cardiac complications	14 (0.1%)	9 (0.3%)	6 (0.6%)	**<0.001***
Renal complications	6 (<0.1%)	9 (0.3%)	7 (0.7%)	**<0.001***
Septic complications	27 (0.2%)	16 (0.5%)	14 (1.4%)	**<0.001***
Urinary tract infections	49 (0.3%)	65 (1.8%)	40 (3.9%)	**<0.001***
Bleeding requiring transfusions	46 (0.3%)	46 (1.3%)	32 (3.1%)	**<0.001***
Mortality	11 (0.1%)	10 (0.3%)	18 (1.7%)	**<0.001***
Reoperations	173 (1.2%)	63 (1.8%)	29 (2.8%)	**<0.001***
Readmissions	258 (1.7%)	154 (4.3%)	63 (6.1%)	**<0.001***
Non-Home discharge	816 (5.4%)	1,087 (30.7%)	710 (69.1%)	**<0.001***

Asterix indicates significance.

Results

A total of 19,585 patients met inclusion criteria: 1,033 (5.3%) were octogenarians (≥80 years), 3,544 (18.1%) were ages 65-79 years, and 15,008 (76.6%) were non-geriatric (age <65 years). Significant differences among these groups were identified in all demographic categories (Table 1) as well as baseline operative/procedural factors (Table 2). Patients with an age ≥80 years were more likely white females with an overall greater comorbidity burden and ASA class when compared to younger patients. Additionally, octogenarian and nonagenarian patients underwent fixation more often in an inpatient setting.

Table 4. Thirty-Day Outcomes After Controlling for Baseline Demographics, Comparing the Adjusted OR for (Age ≥80 Years) and (Age 65-79 Years) With the (Age <65 years) Group.

30-day outcomes	Adjusted OR [95% CI]	P-value
Wound complications		
Age ≥80 years	1.84 [1.10-3.06]	**0.019***
Age 65-79 years	1.15 [0.80-1.65]	0.451
Pulmonary complications		
Age ≥80 years	3.88 [1.99-7.56]	**<0.001***
Age 65-79 years	2.30 [1.31-4.05]	0.004
Thromboembolic complications	y	
Age ≥80 years	0.64 [0.22-1.92]	0.431
Age 65-79 years	1.34 [0.79-2.26]	0.274
Cardiac complications		
Age ≥80 years	1.64 [0.52-5.21]	0.398
Age 65-79 years	0.92 [0.36-2.37]	0.868
Renal complications		
Age ≥80 years	1.96 [0.59-6.44]	**0.015***
Age 65-79 years	5.28 [1.38-20.26]	0.271
Septic complications		
Age ≥80 years	3.72 [1.60-8.63]	**0.002***
Age 65-79 years	1.36 [0.66-2.83]	0.404
Urinary tract infections		
Age ≥80 years	3.06 [1.81-5.16]	**<0.001***
Age 65-79 years	2.24 [1.45-3.44]	**<0.001***
Bleeding requiring transfusion		
Age ≥80 years	1.90 [1.08-3.34]	**0.025***
Age 65-79 years	1.13 [0.70-1.81]	0.628
Mortality		
Age ≥80 years	7.44 [2.66-20.83]	**<0.001***
Age 65-79 years	1.57 [0.59-4.22]	0.369
Reoperations		
Age ≥80 years	1.44 [0.90-2.31]	0.125
Age 65-79 years	0.99 [0.70-1.38]	0.931
Readmissions		
Age ≥80 years	1.65 [1.18-2.31]	**0.004***
Age 65-79 years	1.41 [1.11-1.79]	**0.005***
Non-home discharge		
Age ≥80 years	13.91 [11.46-16.89]	**<0.001***
Age 65-79 years	3.55 [3.12-4.04]	**<0.001***

Asterix indicates significance.

Unadjusted outcomes (Table 3) included significant associations between age ≥80 and wound, pulmonary, cardiac, renal and septic complications, as well as urinary tract infections and bleeding requiring transfusion. Additionally, unadjusted 30-day mortality, reoperations, readmissions and non-home discharges were all significantly associated with age ≥80.

Ensuring the effect of age on 30-day operative outcomes was independent of baseline characteristics and operative/procedural factors (Table 4), multivariate regression was used to compare patients ≥80 with those 65-79 years and <65 years. Final adjusted analysis demonstrated that patients ≥80 years old were at a greater odds of 30-day mortality (OR: 7.44 [95% CI 2.66-20.83]; $p \leq 0.001$), readmissions (OR: 1.65 [95% CI 1.18-2.31]; $p = 0.004$), non-home discharge (OR: 13.91 [95% CI 11.46-16.89]; $p \leq 0.001$), pulmonary complications (OR: 3.88 [95% CI 1.99-7.56]; $p \leq 0.001$), renal complications (OR:

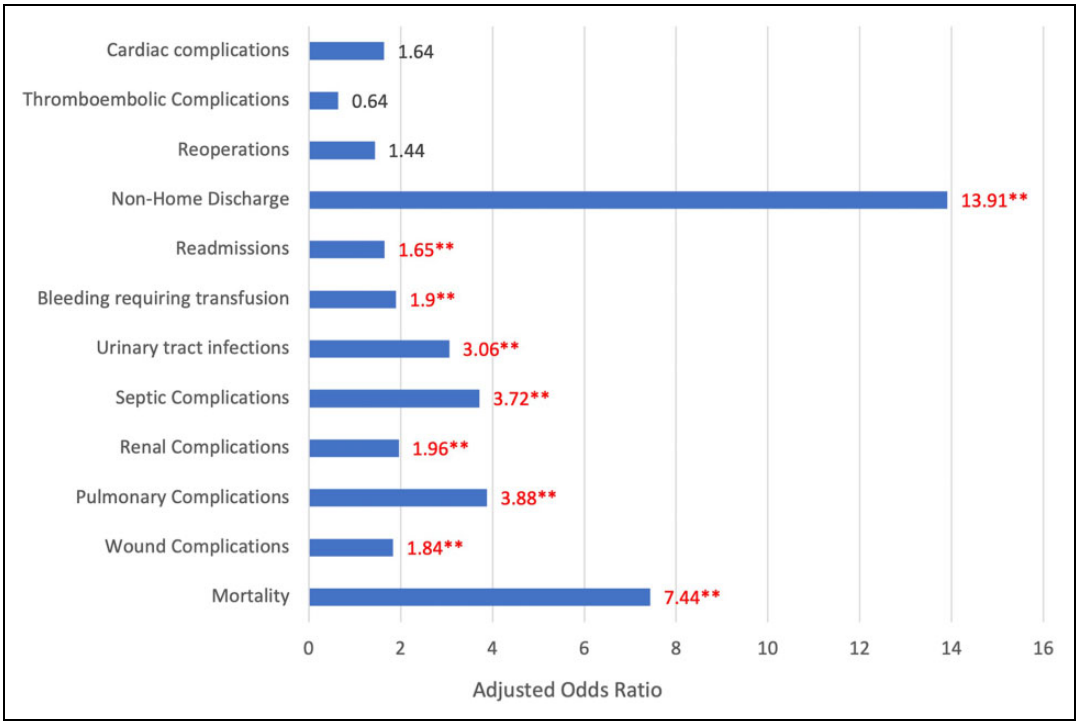

Figure 1. Multi-variate analysis showing adjusted odds ratios comparing 30-day outcomes for patients ≥ 80 with patients <65 years of age. Baseline clinical characteristics were controlled in this analysis. Red values indicate significance and associated P values can be found in Table 4.

1.96 [95% CI 0.59-6.44]; p = 0.015), septic complications (OR: 3.72 [95% CI 1.60-8.63]; p = 0.002), urinary tract infections (OR: 3.06 [95% CI 1.81-5.16]; p ≤ 0.001) and bleeding requiring transfusion (OR: 1.90 [95% CI 1.08-3.34]; p = 0.025). Figure 1 shows a representation of the odds ratios comparing patients ≥80 years to patients <65 years.

Additionally, multivariate analysis was performed comparing patients age 65-79 to patients <65. This revealed a greater odds of readmission (OR: 1.41 [95% CI 1.11-1.79]; p = 0.005), non-home discharge (OR: 3.55 [95% CI 3.12-4.04]; p ≤ 0.001) and urinary tract infections (OR: 2.24 [95% CI 1.45-3.44]; p ≤ 0.001).

Discussion

Operative fixation of unstable ankle fractures has become the accepted standard of care with predictably good surgical outcomes in both the geriatric and non-geriatric populations. However, octogenarian and nonagenarian patients are a special trauma cohort that requires appropriate attention to perioperative medical optimization. A multidisciplinary approach for post-operative recovery in order to minimize the higher rate of complications expected within this population is critical.[15] This study uniquely identifies perioperative outcomes specific to ankle fractures in the octogenarian and nonagenarian populations.

Other studies investigating the outcomes following ORIF for ankle fracture in the geriatric population cautioned similar risk of morbidity and mortality. Gil et al. completed an ACS-NSQIP study comparing outcomes within the geriatric population but with a smaller cohort of patients.[16] They identified that patients age ≥80 when compared to patients 65-79 had higher rates of mortality, revision surgery, length of stay, and blood transfusions within a 30-day follow up period. However, when stratifying patients by ASA class, they found no significant differences between the same groups across all outcomes. Our study also demonstrated differences in ASA class between each age cohort, but after adjusting for baseline characteristics (including ASA class) our results showed greater odds of mortality for patients ≥80 years compared to those <65 years. However, there was no difference in mortality comparing age <65 years to patients 65-79 years after adjusting for baseline characteristics. While our study didn't compare the same age cohorts as Gil et al, we share similar cautionary evidence for ankle fracture ORIF in patients ≥80 years with significant pre-operative comorbidity burden.

Octogenarians who undergo total hip arthroplasty (THA) are known to experience greater medical complications such as urinary tract infections, delirium, myocardial infarction, pneumonia and anemia.[8,17] Kennedy et al. described a "snowballing" of complications in some patients ≥80 years following THA, where multiple sequential adverse events can lead to rapid deterioration. Other studies of nonagenarian patients after hip fracture repair reported increased medical complications, greater risk of mortality (in-hospital through

2-year follow-up) and increased non-home discharges[18] Easterlin et al. demonstrated similar findings in total knee arthroplasty (TKA) for patients recorded in the NSQIP database. Their results indicated that age was an independent risk factor for adverse outcomes following TKA after controlling for comorbid conditions. When compared to non-geriatric patients, they found a significant increase in mortality in patients >85 years as well as an increase in total complications starting at ≥70 years.[9] Mortality, non-home discharge, bleeding, urinary tract infections and pneumonia are all increased following ankle fracture repair, which is comparable to other common orthopedic procedures.

Outpatient fixation of ankle fractures has been widely applied in the general population due to reduced cost and lower post-operative complication rate.[19] Cost savings in outpatient isolated ankle fracture repair is substantial, with a 90-day cost reduction of $5788-$8943 compared to inpatient treatment.[18,20] Patients also benefit from fewer readmissions and ED visits, as well as lower rates of pneumonia and acute renal failure. However, the application of outpatient fixation in the octogenarian population remains limited due to factors such as higher preoperative comorbidity and greater fracture complexity. During our investigation, non-geriatric patients sustained 41.3% unimalleolar fractures compared to 21.2% in octogenarians, underscoring the greater complexity of fracture types in older populations. Octogenarians also experienced higher preoperative comorbidity burdens with 75.8% having an ASA ≥2 compared to 20% of non-geriatric patients. In our study, 21% of octogenarian patients underwent outpatient fixation while prior studies report figures as high as 29.5%. It is clear that many octogenarian patients are at high risk for complications, and outpatient surgery should be carefully considered given patients pre-operative risk factors.

Beyond the weaknesses common to retrospective studies, limitations of this study include those inherent to the NSQIP database. These include the inability to capture complications outside of the 30-day post-operative window, which could change the estimate of long-term operative success in this population. Additionally, due to the limiting eligibility criteria for NSQIP sites and differences in variable collection between hospitals, the data may not represent the same complication rates for smaller or more rural hospital systems. With more extensive pre-operative optimization necessary for older adults, delays in surgery could be a potential source of confounding. Future studies exploring outcomes beyond the 30-day timeframe as well as the economic burden of readmission in octogenarian patients are needed.

Our data show that octogenarians and nonagenarians (age ≥80) are a fundamentally distinct and vulnerable age group that is at higher risk of complications, readmissions, mortality and non-home discharges compared to other geriatric (65-79 years) and non-geriatric (<65 years) patients. It is critical for providers to recognize and understand the importance of preoperative counseling as well as risk-stratification in this vulnerable patient population.

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References

1. Belatti DA, Phisitkul P. Economic burden of foot and ankle surgery in the US Medicare population. *Foot Ankle Int*. 2014;35(4):334-340. doi:10.1177/1071100713519777
2. Sporer SM, Weinstein JN, Koval KJ. The geographic incidence and treatment variation of common fractures of elderly patients. *J Am Acad Orthop Surg*. 2006;14(4):246-255. doi:10.5435/00124635-200604000-00006
3. Florence CS, Bergen G, Atherly A, Burns E, Stevens J, Drake C. Medical costs of fatal and nonfatal falls in older adults. *J Am Geriatr Soc*. 2018;66(4):693-698. doi:10.1111/jgs.15304
4. Etzioni DA, Liu JH, Maggard MA, Ko CY. The aging population and its impact on the surgery workforce. *Ann Surg*. 2003;238(2):170-177. doi:10.1097/01.SLA.0000081085.98792.3d
5. van de Kerkhove MP, Antheunis PS, Luitse JS, Goslings JC. Hip fractures in nonagenarians: perioperative mortality and survival. *Injury*. 2008;39(2):244-248. doi:10.1016/j.injury.2007.07.009
6. Tay YW, Hong CC, Murphy D. Functional outcome and mortality in nonagenarians following hip fracture surgery. *Arch Orthop Trauma Surg*. 2014;134(6):765-772. doi:10.1007/s00402-014-1982-z
7. Grossman M, Scaff DW, Miller D, Reed J III, Hoey B, Anderson HL III. Functional outcomes in octogenarian trauma. *J Trauma*. 2003;55(1):26-32. doi:10.1097/01.TA.0000072109.52351.0D
8. Rubin LE, Blood TD, Defillo-Draiby JC. Total hip and knee arthroplasty in patients older than age 80 years. *J Am Acad Orthop Surg*. 2016;24(10):683-690. doi:10.5435/JAAOS-D-15-00278
9. Easterlin MC, Chang DG, Talamini M, Chang DC. Older age increases short-term surgical complications after primary knee arthroplasty. *Clin Orthop Relat Res*. 2013;471(8):2611-2620. doi:10.1007/s11999-013-2985-8
10. Cavo MJ, Fox JP, Markert R, Laughlin RT. Association between diabetes, obesity, and short-term outcomes among patients

surgically treated for ankle fracture. *J Bone Joint Surg Am. 17* 2015;97(12):987-994. doi:10.2106/JBJS.N.00789

11. Kadakia RJ, Hsu RY, Hayda R, Lee Y, Bariteau JT. Evaluation of one-year mortality after geriatric ankle fractures in patients admitted to nursing homes. *Injury*. 2015;46(10):2010-2015. doi:10.1016/j.injury.2015.05.020
12. Aigner R, Salomia C, Lechler P, Pahl R, Frink M. Relationship of prolonged operative time and comorbidities with complications after geriatric ankle fractures. *Foot Ankle Int*. 2017;38(1):41-48. doi:10.1177/1071100716667315
13. Lorente A, Palacios P, Lorente R, Mariscal G, Barrios C, Gandia A. Orthopedic treatment and early weight-bearing for bimalleolar ankle fractures in elderly patients: quality of life and complications. *Injury*. 2019;51(2):548-553. doi:10.1016/j.injury.2019.11.028
14. Steinberg SM, Popa MR, Michalek JA, Bethel MJ, Ellison EC. Comparison of risk adjustment methodologies in surgical quality improvement. *Surgery*. 2008;144(4):662-667; discussion 662-7. doi:10.1016/j.surg.2008.06.010
15. Grigoryan KV, Javedan H, Rudolph JL. Orthogeriatric care models and outcomes in hip fracture patients: a systematic review and meta-analysis. *J Orthop Trauma*. 2014;28(3):e49-e55. doi:10.1097/BOT.0b013e3182a5a045
16. Gil JA, Goodman AD, Kleiner J, Walsh DF, Kosinski LR, Hsu R. Mortality and morbidity of surgical management of geriatric ankle fractures. *J Am Acad Orthop Surg*. 2020;28(16):678-683. doi:10.5435/JAAOS-D-19-00048
17. Kennedy JW, Johnston L, Cochrane L, Boscainos PJ. Outcomes of total hip arthroplasty in the octogenarian population. *Surgeon*. 2013;11(4):199-204. doi:10.1016/j.surge.2012.12.005
18. Varacallo MA, Mattern P, Acosta J, Toossi N, Denehy KM, Harding SP. Cost determinants in the 90-day management of isolated ankle fractures at a large urban academic hospital. *J Orthop Trauma*. 2018;32(7):338-343. doi:10.1097/BOT.0000000000001186
19. Bettin C, Nelson R, Rothberg D, Barg A, Lyman M, Saltzman C. Cost comparison of surgically treated ankle fractures managed in an inpatient versus outpatient setting. *J Am Acad Orthop Surg*. 2019;27(3):e127-e134. doi:10.5435/JAAOS-D-16-00897
20. Malik AT, Quatman CE, Khan SN, Phieffer LS, Rao P, Ly TV. Outpatient versus inpatient surgical fixation of isolated ankle fractures: an analysis of 90-day complications, readmissions, and costs. *J Foot Ankle Surg*. 2020;59(3):502-506. doi:10.1053/j.jfas.2019.09.030