

Hip fracture care during the COVID-19 pandemic: retrospective cohort and literature review

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Abstract

Objectives: The goal of this study was to investigate whether the COVID-19 pandemic has affected hip fracture care at a Level I Trauma hospital. The secondary goal was to summarize the published hip fracture reports during the pandemic.

Design: A retrospective cohort study.

Setting: Level I Trauma Center.

Patients/Participants: Eighty-six operatively treated hip fracture patients age ≥ 65 years, occurring from January 17 to July 2, 2020.

Intervention (if any): N/A.

Main Outcome Measurements: We defined 3 phases of healthcare system response: pre-COVID-19 (period A), acute phase (period B), and subacute phase (period C). The primary outcome was 30-day mortality. Clinical outcomes including time to surgery (TTS) and length of stay (LOS) were extracted from the electronic medical record.

Results: Twenty-seven patients from Period A, 27 patients from Period B, and 32 patients from Period C were included. The 30-day mortality was not statistically different. The mean TTS was 20.0 \pm 14.3 hours and was the longest in Period C (22.1 \pm 9.8 hours), but the difference was not statistically significant. The mean LOS was 113.0 \pm 66.2 hours and was longest in Period B (120.9 \pm 100.6 hours). However, the difference was not statistically significant.

Conclusions: The 30-day mortality, TTS, and LOS were not statistically different across multiple phases of pandemic at a level 1 trauma center. Our results suggest that we successfully adapted new protocol changes and continued to provide evidence-based care for hip fracture patients. Our results were comparable with that of other authors around the world.

Keywords: COVID-19, hip fracture, length of stay, time to surgery

1. Introduction

Arriving at the 1st anniversary of the start of the COVID-19 pandemic in the United States provides an opportunity to reflect on what we have learned in the care of geriatric hip fracture patients.^[1,2] To date, over 105 million people worldwide have

been infected, and on February 22, 2021, the US surpassed 500,000 deaths due to the virus.^[3] Although most cases of orthopaedic trauma declined and stay-at-home orders were instituted almost universally during the pandemic, reports of hip fracture volumes were observed to remain relatively consistent with prepandemic volumes.^[4-6] These observed volume change differences have been attributed to the fact that hip fractures due to low-energy mechanisms occur most frequently in the patients' home.^[7,8]

There has been much interest in the effects of the COVID-19 pandemic on hip fracture outcomes and delivery of care. As expected, those with COVID-19 infection and hip fracture have been shown to demonstrate worse outcomes than their COVID-19-free peers, primarily seen as increases in 30-day mortality.^[9-12] In addition to impacting 30-day mortality rates, COVID-19 impacted key healthcare delivery metrics known to impact hip fracture outcomes, specifically time to surgery (TTS). Operating room capacity and staffing decreased significantly in many hospitals in response to COVID-19 patient care needs and staff infections.^[13-15] In some reports, the hip fracture management changes during the COVID-19 pandemic impacted mortality and morbidity even in COVID-19-negative patients.^[16] However, the evidence is conflicting, and research analyzing the COVID-19 pandemic impact on hip fracture patient care in the US is still lacking.

The goal of this study was to assess the impact of the COVID-19 pandemic on operative hip fracture care at a Minnesota Level I Trauma hospital, specifically analyzing variances in TTS, length

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of stay (LOS), and 30-day mortality in geriatric hip fracture patients. Secondly, we sought to provide a summary of the published reports on global hip fracture outcomes during the COVID-19 pandemic period. Through this literature review and summary, the authors sought to gain insight into challenges and changes to standardized hip fracture care pathways which occurred due to the global pandemic.

2. Materials and methods

2.1. Study design and participants

A retrospective cohort study was approved by the institutional review board (HealthPartners IRB; Q12017), and the study was conducted at a metropolitan Level I Trauma Center in Minnesota. Informed consent requirement was waived by the IRB due to the nature of the study. Included participants were patients age ≥ 65 years presenting with a radiographic diagnosis of a proximal femoral fracture (31-A and 31-B according to the OTA/AO classification^[17]) from a low-energy mechanism who were treated operatively over 24 weeks from January 17, 2020 to July 2, 2020. Exclusion criteria included patients with high-energy trauma, periprosthetic or peri-implant fracture, greater trochanter or lesser trochanter fracture, age less than 65 years, nonsurgical cases, or revision surgery for prior hip fracture. All patients age ≥ 65 years old who were admitted for a hip fracture during the study period were screened for eligibility and inclusion and exclusion criteria were applied.

Previously published data from our group analyzing operative outcomes in hip fracture patients at a community hospital within the same metropolitan area and health system were also used for comparison in an exploratory analysis. The methods described above (including time periods, inclusion and exclusion criteria, and variables) are identical and approved under the same IRB.^[18]

The World Health Organization officially recognized COVID-19 as an international emergency on March 11, 2020.^[19] Subsequently, on March 13, 2020, Minnesota's Governor Tim Walz declared a peacetime emergency to prepare for the COVID-19 pandemic in Minnesota.^[20] We defined 3 phases of the healthcare system response to the pandemic: prepeacetime emergency, acute phase of the state of emergency, and subacute phase of the state of emergency. Prepeacetime emergency (Period A, January 7 to March 12, 2020) was defined as the 8 weeks preceding March 13. The acute phase (Period B, March 13 to May 7, 2020) was defined as 8 weeks after the peacetime emergency declaration and was characterized by new protocol development and rapidly evolving practices during the early stages of the crisis. The subacute phase (Period C, May 8 to July 2, 2020) was defined as 8 weeks after the acute phase and represented a timeframe with less frequent changes in practice and protocols at the trauma center.

2.2. Data collection

Demographic, clinical, laboratory, treatment, and outcomes data were extracted from electronic medical records by the site investigators using a customized data collection form.

2.3. Variables

The primary outcome of this study was 30-day mortality after hip fracture in our eligible participants and included in-hospital mortality. Demographic, clinical, and functional variables were extracted from the electronic medical record, including age at

presentation, sex, race, body mass index, and comorbidities. The presence of the following comorbidities was recorded based on documentation in the electronic medical record: diabetes, hypertension, heart failure, cognitive impairment (including mild dementia and more advanced diagnoses), cancer, metastatic cancer, chronic obstructive pulmonary disease, stroke, depression, Parkinson disease, and chronic kidney disease.^[21,22] In addition, the Charlson Comorbidity Index^[23] was calculated for each patient. Injury information was extracted, including mechanism and fracture type (OTA/AO classification^[17]). The diagnosis of COVID-19 was determined by a polymerase chain reaction test from nares swab samples. Variables related to the timing and delivery of care were also collected, including TTS (defined as the number of hours from the first presentation to the hospital to surgery), and LOS, surgical delay was defined as a surgery occurring more than 24 hours after admission. Reasons for surgical delay were investigated.

2.4. Statistical analysis

Continuous variables were presented as the mean and the standard deviation, and categorical variables were presented as the number and percentage. Chi-squared tests were used to compare categorical variables. To compare the differences between each of 3 different periods, a pair-wise comparison was performed. Statistical analysis of study outcomes was performed using the independent-samples *t* test for continuous variables with normal distributions, while the Mann-Whitney *U* test was used for continuous variables that were not normally distributed. All analyses were performed using standardized formulas). Statistical tests were considered significant at $P < .05$ (2 tails).

2.5. Literature review method

We performed a review of the literature using PubMed and Google Scholar. Search terms included: hip fracture AND COVID. Studies with the publication year 2020 through December 2020 were included. For completeness, we also searched citations of the articles. We focused on studies that discussed hip fracture specifically and not overall orthopaedic trauma during the COVID-19 period. Abstracts were screened for relevance and if determined applicable, full-text versions of the studies were evaluated. After completing the literature search, articles were formatted into a spreadsheet to help organize variables and again confirm pertinence to the subject.

3. Results

A total of 86 patients met inclusion criteria: 27 patients from Period A, 27 patients from Period B, and 32 patients from Period C. Twenty-three patients were excluded from the study. Thirteen were due to fracture type (i.e., greater trochanter fracture or periprosthetic fracture) and 10 were treated nonsurgically. Of the nonoperative patients, 6 were from period A and were not tested for COVID-19, 2 were from period B with 1 not tested for COVID-19 and 1 testing negative, and 2 were from period C (both testing negative for COVID-19). The nonsurgical patients not tested for COVID-19 did not have any reported respiratory symptoms and potential COVID-19 infection was not part of the reasoning behind pursuing nonsurgical care.

Demographic information for the 3 periods is presented in Table 1. Data is presented in aggregate and broken down by period. Overall, there was no significant difference in demo-

Table 1
Trauma center demographics

Variable	Total (N=86)	Period A (N=27)	Period B (N=27)	Period C (N=32)	Pairwise comparison		
					A v B	A v C	B v C
Age (SD) (years)	82 (± 7.9)	81.2 (± 7.95)	82.1 (± 8.4)	83 (± 7.74)	0.69	0.38	0.67
Female	65 (75.6%)	19 (70.3%)	19 (70.3%)	27 (84.4%)	1.00	0.20	0.20
Male	21 (24.4%)	8 (29.6%)	8 (29.6%)	5 (15.6%)	1.00	0.20	0.20
BMI (SD) (kg/m ²)	26 (± 6.1)	27 (± 6.25)	25.7 (± 7.1)	26 (± 5.2)	0.48	0.51	0.85
Type of fracture							
Femoral Neck	42 (48.8%)	13 (48.1%)	17 (63.0%)	12 (37.5%)	0.27	0.41	0.05
Trochanteric	44 (51.2%)	14 (51.9%)	10 (37.0%)	20 (62.5%)	0.27	0.41	0.05
COVID-19 test on admission							
Detected	3 (3.5%)	0	0	3 (9.4%)			
Not detected	45 (52.3%)	0	16 (59.3%)	29 (90.6%)			
Not tested	38 (44.2%)	27 (100%)	11 (40.7%)	0			
Comorbidities							
≥3	57 (66.2%)	17 (63.0%)	19 (70.4%)	21 (65.6%)	0.56	0.83	0.70
<3	29 (33.7%)	10 (37.0%)	8 (29.6%)	11 (34.3%)	0.56	0.83	0.70

graphic data between the 3 groups across the 3 time periods. The mean age was 82 years old (SD 7.9) with a minimum age of 65-years-old and a maximum of 99-years-old. Women represented 75.6% of total patients during the study period, and 86.0% were Caucasian. Mean BMI was 26 kg/m² (SD 6.1). Forty-two (48.8%) fractures were located in the femoral neck, and 44 (51.2%) fractures were intertrochanteric.

No patients were tested for SARS-CoV-2 during Period A due to the pre-COVID-19 period. During Period B, 40.7% of patients were not tested and underwent surgery without a test, while 59.3% of patients underwent testing and were negative. There were no positive COVID-19 test results during Period B. At this hospital, the test was not widely available during this period, and patients who did not meet testing criteria (i.e., no respiratory symptoms, nor fever) were not tested. By Period C, testing was more widely available, new hospital protocols for testing were in place, and all patients were tested for the SARS-CoV-2 virus at the time of admission. In Period C, the virus was detected in 3 patients (9.4%), and the virus was not detected in 29 (90.6%). Due to the low rate of viral testing in our study period and subjects we did not compare results and outcomes in COVID-19+ hip fracture patients.

We identified a set of commonly occurring comorbidities in the study population. These included diabetes, hypertension, heart failure, cognitive impairment, cancer, metastatic cancer, chronic obstructive pulmonary disease, stroke, depression, Parkinsons disease, and chronic kidney disease. In total, 57 patients (66.2%) had 3 or more comorbidities at baseline. The number of patients who had 3 or more comorbidities was not statistically different across the 3 groups. The mean Charlson Comorbidity Index for the entire cohort was 1.0 (range 0–8). The mean Charlson Comorbidity Index and range for each period was similar, A: 1.0 (0–7), B: 1.0 (0–7), C: 2.0 (0–8).

Clinical outcomes for patients following fixation of hip fracture are presented in Table 2. Five patients (5.8%) died within 30 days of surgery across the study period. The 30-day mortality was not statistically different across 3 periods ($P = .30$, $P = .22$, $P = .90$). The mean TTS was 20 hours (SD 14.3) and was the longest in Period C – 22.1 hours (SD 9.8). However, the TTS difference was not statistically significant ($P = .53$, $P = .12$, $P = .78$). The mean LOS across all 3 periods was 113.0 hours (SD 66.2). The longest LOS was in Period B—120.9 hours (SD 9.8), but the difference was not significant ($P = .64$, $P = .79$, $P = .50$).

In comparison with previously reported data on hip fractures during the COVID-19 pandemic in an elderly population at a community hospital,^[18] there were no statistically significant differences in demographics or comorbidities between patients at the trauma center and patients at the community hospital (data not shown). In contrast to our findings from the level 1 trauma center, the authors found that TTS and LOS increased during the pandemic in the community hospital. In Table 3, we compared prepandemic to pandemic period outcomes and care metrics for each hospital. A significant difference was found only in LOS at the community hospital ($P = .034$).

3.1. Literature review results

Finally, we reviewed worldwide hip fracture and COVID-19 literature through December 2020 (Table 4).^[6,9-13,24-36] We specifically selected peer-reviewed manuscripts that reported time to surgery, length of stay, and 30-day mortality in operatively treated hip fracture patients during the pandemic time period. Forty-six reports were identified during an initial search. Nineteen reports were determined to meet appropriate criteria for inclusion. The majority (12 of 19%–63%) of the reports were from Europe, 1 from Asia, and only 2 other studies published US data.

Table 2
Trauma center clinical outcomes

Outcomes	Total (N=86)	Period A (N=27)	Period B (N=27)	Period C (N=32)	Pairwise comparison		
					A v B	A v C	B v C
30-d mortality	5 (5.8%)	3 (11.1%)	1 (3.7%)	1 (3.1%)	0.30	0.22	0.90
TTS (SD) (hours)	20.0 (± 14.3)	18 (± 9.9)	20.8 (± 21.0)	22.1 (± 9.8)	0.53	0.12	0.78
LOS (SD) (hours)	113.0 (±66.2)	111 (± 45.7)	120.9 (± 100.6)	108 (± 40.9)	0.64	0.79	0.50

Table 3

Trauma center and community hospital^[18] pre-Covid (A) to post-Covid (B/C) pair-wise comparisons

Outcomes	Trauma center N = 86			Community hospital N = 125		
	A (N = 27)	B/C (N = 59)	P value	A (N = 41)	B/C (N = 81)	P value
30-d mortality	3 (11.1%)	2 (3.4%)	.16	3 (7.3%)	11 (13.1%)	.34
TTS (SD) (hours)	18.0 (± 9.9)	21.5 (±15.8)	.42	23.1 (± 13.3)	28.9 (± 24.1)	.17
LOS (SD) (hours)	111.0 (± 45.7)	113.8 (±73.9)	.83	109.4 (± 35.4)	135.0 (± 84.1)	.03

BMI = body mass index; LOS = length of stay; SD = standard deviation; TTS = time to surgery.

Table 4

Summary of hip fracture and COVID global literature

Author	Country/ region	Time period	Number of patients	Covid(+) hip fractures			All hip fractures			Hip fx vol
				Mortality	LOS	TTS	Mortality	LOS	TTS	
United Kingdom/England/Scotland										
Cheruvu et al (August, 2020) ^[24]	England	March 1 to April 20, 2016–2020	288					↑ (P<.001)		ND*
Craig et al (December, 2020) ^[13]	United Kingdom	March 24 to May 23, 2015–2020	700	↑ (P=.05)			ND (P=.71)		↓*	ND*
Malik-Tabassum et al (July, 2020) ^[6]	United Kingdom	March 23 to May 11, 2018–2020	242				ND (P=.157)	↓ (P<.001)	ND (P=.490)	↓*
Ogliari et al (October, 2020) ^[25]	United Kingdom	January 1 to March 24 March 25 to May 12, 2015–2020	1752							ND*
Chui et al (June, 2020) ^[26]	United Kingdom	March 31, 2020 to April 30, 2020	47	ND (P=.097)	ND (P=.059)	↑ (P=.015)				
Hall et al (July, 2020) ^[10]	Scotland	March 01, 2020 to April 15, 2020	317	↑ (P<.001)				↓ (P<.001)	ND*	ND*
Kayani et al (July, 2020) ^[27]	United Kingdom	February 01, 2020 to April 20, 2020	442	↑ (P<.001)	↑ (P<.001)	ND (P=.918)				
Mamarelis et al (December, 2020) ^[28]	United Kingdom	March 2020 to April 2020	41	↑ (P=.004)		ND (P=.386)				
Narang et al (August, 2020) ^[12]	United Kingdom	March 01, 2019 to April 30, 2019 vs March 01, 2020 to April 30, 2020	1346	↑ (P<.001)			↓ (P=.001)	ND (P=.67)	↑ (P<.001)	↓*
Rasidovic et al (November, 2020) ^[29]	England	March 01, 2020 to April 06, 2020	404	↑ (P<.001)	↑ (P<.001)	ND (P=.756)				
Thakrar et al (July, 2020) ^[30]	United Kingdom	March 15 to April 13, 2018–2020	197	↑ (P=.002)			↑ (P=.001)			ND (P=.349)
Ward et al (November, 2020) ^[31]	United Kingdom	March 01, 2020 to May 31, 2020	132	↑ (P<.000)	↑ (P<.000)					
Remaining EU										
Maniscalco et al (May, 2020) ^[32]	Italy	February 22, 2019 to April 18, 2019 vs. February 22, 2020 to April 18, 2020	290					↑*		↓*
Muñoz Vives et al (July, 2020) ^[11]	Spain	March 14, 2020 to April 04, 2020	136	↑*		ND (P=.844)				
Segarra et al (September, 2020) ^[33]	Spain	February 01, 2019 to April 15, 2019 vs February 01, 2020 to April 15, 2020	138				ND (P=.845)	ND (P=.115)	↑ (P=.034)	ND*
Asia										
Wong et al (June, 2020) ^[34]	Singapore	2 mo Pre- February 07, 2020 vs 2 mo post- February 07, 2020	111						ND (P=.084)	↓*
South America										
Siullitel et al (August, 2020) ^[35]	Argentina	December 19 to May 20	160				↑ (P=.002)	↑ (P=.001)	↑ (P=.001)	ND*
North America										
Egol et al (May, 2020) ^[9]	United States	February 01, 2019 to April 15, 2019 vs February 01, 2020 to April 15, 2020	253	↑ (P<.001)	↑ (P<.001)	↑ (P<.001)	↑ (P=.005)	ND (P=.959)	ND (P=.884)	↑*
Lebrun et al (August, 2020) ^[36]	United States	March 20, 2020 to April 24, 2020	59	↑ (P=.001)	ND (P=.43)	ND (P=.11)				
Minneapolis/St. Paul Community Hospital (March, 2021) ^[18]	United States	January 17, 2020 to July 02, 2020	125				ND (P=.34)	↑ (P=.034)	ND (P=.17)	ND*
— Authors' Data— Trauma Center	United States	January 17, 2020 to July 02, 2020	86				ND (P=.16)	ND (P=.83)	ND (P=.42)	ND*

Hip Fx Vol = hip fracture volumes; LOS = length of stay; ND = no finding of significant difference; TTS = time to surgery.

* P values not reported.

4. Discussion

We investigated the effects of the COVID-19 pandemic on geriatric hip fracture care at a level 1 trauma center in Minnesota. Our primary aim was to assess 30-day mortality during discrete phases of the pandemic, and to evaluate other important measures of healthcare outcomes, including TTS and LOS. We also compared our data to that of a community hospital within the same healthcare system and to previously published data from other investigators worldwide.

The number of patients presenting with hip fractures to the trauma center remained constant during the pandemic. We found no statistically significant difference in 30-day mortality, TTS, and LOS between the 3 periods of our study at the trauma center.

We examined overall 30-day mortality in patients regardless of COVID-19 infection status. This method has been used by other authors. Some found increased mortality in overall hip fracture patients during the pandemic,^[9,30,35] while others found no difference in mortality pre and during the pandemic,^[6,12,13,33] similar to our results. Slullitel et al^[35] reported an increase in mortality concomitant with patients who were frailer at baseline.^[35] Other authors reported no difference in mortality rates suggesting that their hospitals adapted rapidly to new algorithms and continued delivering protocolized hip fracture care despite the pandemic.^[6]

TTS is an important marker of geriatric hip fracture care. Prior to the COVID-19 pandemic, the authors have found a significant increase in morbidity and mortality when TTS was greater than 24 hours.^[37] Our mean TTS was 20.0 hours (SD 14.3). Although fluctuation did occur, the TTS was within 24 hours even in Period B and Period C. Within the global literature, TTS during the pandemic varied with some authors reporting faster,^[13] slower,^[12,33] and equivalent times^[6,9,10,34,35] to surgical fixation (Table 4). In the presented report, our level 1 trauma center preserved capacity to provide timely access to OR for hip fracture patients notwithstanding protocol changes that included the reduction of operating rooms for orthopaedic trauma from 4 ORs to 1. However, the number of orthopaedic providers remained constant during the pandemic response.

In other US reports, Egol et al^[9] reported no difference in TTS for all hip fracture patients (mean=33.6 hours) but increased TTS in their COVID-19-positive hip fracture patients (64.8 hours) as compared with COVID-19 negative (26.4 hours). The authors have posited that medical optimization of COVID-19 patients and the lack of familiarity with the evolving COVID-19 protocols caused delays.^[9,32] Previous authors have noted decreases in community trauma, besides hip fractures, during the pandemic which was also true at our trauma center. This likely contributed to our center's ability to adapt to new protocols successfully while maintaining timely surgical fixation for geriatric hip fracture patients.^[25]

Length of stay (LOS) of hip fracture patients is another important indicator of hip fracture care. The length of stay varied widely around the world during the pandemic. Some studies report an increased LOS during the COVID-19 pandemic,^[18,35] while others found a decreased LOS,^[10,24] or no significant difference between periods.^[9,33] We attribute these wide-ranging results to differing hospital-by-hospital protocols and workload effects of the pandemic. Some authors attribute decreased LOS during the pandemic to an emphasis on rapid discharge, helping to prevent patients from acquiring COVID-19 infection, along with increased staff availability due to decreases in other forms of orthopaedic trauma.^[10,35] Additionally, some healthcare systems received

additional funding from the government to aid in expediting discharges to free up acute care beds.^[35] On the other hand, other hospitals may have had more staffing shortages (possibly due to staff COVID-19 infections or redistribution of staff) that prevented prioritizing timely discharge of hip fracture patients.

5. Limitations

Many studies, ours included, are limited in the strength of conclusions and level of evidence by their retrospective nature and relatively small population size.

Additionally, the burden of the pandemic was unequally distributed, especially in the spring of 2020, which may explain why authors in New York City found a significant increase in 30-day and inpatient mortality for both COVID-19 (+) hip fracture patients and COVID-19 (-) hip fracture patients, compared with the same time period in 2019.^[9] Our hospital in Minnesota was not as severely overwhelmed as hospitals in New York City during the same time period and indeed our state experienced peak COVID-19 case numbers and admissions in the fall of 2020.^[38] Although the spring of 2020 does not correlate with peak case volumes in Minnesota, our system still underwent a large policy shift in response to the Governor's peacetime emergency declaration that significantly affected how we delivered care, including trauma patient care. Our study is focused on analyzing the effects of policy changes on hip fracture outcomes during the pandemic. A future direction for our study group may be to compare hip fracture metrics during our state's pandemic surge period (fall of 2020) to that of other authors during their state or country's own surge period without focusing on specific dates.

6. Conclusion

In this retrospective study of geriatric hip fracture patients presenting to a trauma center, we showed no difference in 30-day mortality and critical aspects of hip fracture care, such as TTS and LOS, during multiple phases of the COVID-19 pandemic response in Minnesota. Our results indicated that we successfully continued to provide protocolized care for geriatric hip fracture patients during the pandemic. We also compared our data with that of other authors around the world. Although challenging in the midst of a pandemic, adhering to principles of hip fracture care as outlined by the AAOS and maintaining timely hip fracture care remains essential to decreased mortality and improved outcomes in the geriatric population.^[39]

References

1. WHO | Novel Coronavirus – China. WHO. Accessed March 22, 2021. <http://www.who.int/csr/don/12-january-2020-novel-coronavirus-china/en/>
2. Zhu N, Zhang D, Wang W, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med.* 2020;382:727–733.
3. COVID-19 Map. Johns Hopkins Coronavirus Resource Center. Accessed March 22, 2021. Available at: <https://coronavirus.jhu.edu/map.html>
4. Haskel JD, Lin CC, Kaplan DJ, et al. Hip fracture volume does not change at a New York City level 1 trauma center during a period of social distancing. *Geriatr Orthop Surg Rehabil.* 2020;11:2151459320972674.
5. Kumar Jain V, Lal H, Kumar Patralekh M, et al. Fracture management during COVID-19 pandemic: a systematic review. *J Clin Orthop Trauma.* 2020;11 (suppl 4):S431–S441.
6. Malik-Tabassum K, Crooks M, Robertson A, et al. Management of hip fractures during the COVID-19 pandemic at a high-volume hip fracture unit in the United Kingdom. *J Orthop.* 2020;20:332–337.

7. Cummings SR, Melton LJ. Epidemiology and outcomes of osteoporotic fractures. *Lancet*. 2002;359:1761–1767.
8. Lofthus CM, Osnes EK, Falch JA, et al. Epidemiology of hip fractures in Oslo, Norway. *Bone*. 2001;29:413–418.
9. Egol KA, Konda SR, Bird ML, et al. Increased mortality and major complications in hip fracture care during the COVID-19 pandemic: a New York city perspective. *J Orthop Trauma*. 2020;34:395–402.
10. Hall AJ, Clement ND, Farrow L, et al. IMPACT-Scot report on COVID-19 and hip fractures. *Bone Joint J*. 2020;102-B:1219–1228.
11. Muñoz Vives JM, Jornet-Gibert M, Cámara-Cabrera J, et al. Mortality Rates of Patients with Proximal Femoral Fracture in a Worldwide Pandemic: Preliminary Results of the Spanish HIP-COVID Observational Study. *J Bone Joint Surg Am*. 2020;102:e69.
12. Narang A, Chan G, Aframian A, et al. Thirty-day mortality following surgical management of hip fractures during the COVID-19 pandemic: findings from a prospective multi-centre UK study. *Int Orthop*. 2021;45:23–31.
13. Craig J, Maguire M, Shevlin SP, et al. The effects of COVID-19 on hip fracture management and mortality in a regional trauma centre. *Anaesthesia*. 2020;76:710–711.
14. Greenhalgh M, Dupley L, Unsworth R, et al. Where did all the trauma go? A rapid review of the demands on orthopaedic services at a UK Major Trauma Centre during the COVID-19 pandemic. *Int J Clin Pract*. 2020;75:e13690.
15. Liow MHL, Tay KKK, Yeo NEM, et al. Ensuring business continuity of musculoskeletal care during the COVID-19 pandemic: experience of a tertiary orthopaedic surgery department in Singapore. *JBJS Open Access*. 2020;5:e0050–e150.
16. Lim SM, Tan M, Sze YL, et al. Effects of the COVID-19 pandemic on COVID-19 negative geriatric patients with hip fractures. *J Frailty Aging*. 2021;10:75–76.
17. Meinberg EG, Agel J, Roberts CS, et al. Fracture and Dislocation Classification Compendium-2018. *J Orthop Trauma*. 2018;32 (suppl 1): S1–S170.
18. Onizuka N, Topor LN, Schroder LK, et al. Outcomes of COVID-19 negative hip fracture patients during the acute and subacute pandemic. *Geriatric Orthop Surg Rehabil*. 2021;12:1–8.
19. World Health Organization. *Coronavirus Disease 2019 (COVID-19) Situation Report*.; 2020:1-9. Accessed March 22, 2021. Available at: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf?sfvrsn=1ba62e57_10
20. COVID-19 news updates. Office of Governor Tim Walz and Lt. Governor Peggy Flanagan. Accessed March 21, 2021. Available at: <https://mn.gov/governor/covid-19/news/#/detail/appId/1/id/423050>
21. Woods NF, LaCroix AZ, Gray SL, et al. Frailty: emergence and consequences in women aged 65 and older in the Women's Health Initiative Observational Study. *J Am Geriatr Soc*. 2005;53:1321–1330.
22. Edelmuth SVCL, Sorio GN, Sprovieri FAA, et al. Comorbidities, clinical interurrences, and factors associated with mortality in elderly patients admitted for a hip fracture. *Rev Bras Ortop*. 2018;53:543–551.
23. Charlson M, Szatrowski TP, Peterson J, et al. Validation of a combined comorbidity index. *J Clin Epidemiol*. 1994;47:1245–1251.
24. Cheruvu MS, Bhachu DS, Mulrain J, et al. Effect of COVID-19 on a rural orthopaedic hip fracture service. *Bone Jt Open*. 2020;1:500–507.
25. Ogliairi G, Lunt E, Ong T, et al. The impact of lockdown during the COVID-19 pandemic on osteoporotic fragility fractures: an observational study. *Arch Osteoporos*. 2020;15:156.
26. Chui K, Thakrar A, Shankar S. Evaluating the efficacy of a two-site ("COVID-19" and "COVID-19-free") trauma and orthopaedic service for the management of hip fractures during the COVID-19 pandemic in the UK. *Bone Jt Open*. 2020;1:190–197.
27. Kayani B, Onochie E, Patil V, et al. The effects of COVID-19 on perioperative morbidity and mortality in patients with hip fractures. *Bone Joint J*. 2020;102-B:1136–1145.
28. Mamarelis G, Oduoza U, Chekuri R, et al. Mortality in patients with proximal femoral fracture during the COVID-19 pandemic: A U.K. hospital's experience. *JB JS Open Access*. 2020;5:e20.00086.
29. Rasidovic D, Ahmed I, Thomas C, et al. Impact of COVID-19 on clinical outcomes for patients with fractured hip: a multicentre observational cohort study. *Bone Jt Open*. 2020;1:697–705.
30. Thakrar A, Chui K, Kapoor A, et al. Thirty-day mortality rate of patients with hip fractures during the COVID-19 pandemic: a single centre prospective study in the United Kingdom. *J Orthop Trauma*. 2020;34:e325–e329.
31. Ward AE, Tadross D, Wells F, et al. The impact of COVID-19 on morbidity and mortality in neck of femur fracture patients: a prospective case-control cohort study. *Bone Jt Open*. 2020;1:669–675.
32. Maniscalco P, Poggiali E, Quattrini F, et al. Proximal femur fractures in COVID-19 emergency: the experience of two Orthopedics and Traumatology Departments in the first eight weeks of the Italian epidemic. *Acta Biomed*. 2020;91:89–96.
33. Segarra B, Ballesteros Heras N, Viadel Ortiz M, et al. Are hospitals safe? A prospective study on SARS-CoV-2 prevalence and outcome on surgical fracture patients: a closer look at hip fracture patients. *J Orthop Trauma*. 2020;34:e371–e376.
34. Wong SHJ, Fang XC, Yee KHD, et al. Hip fracture time-to-surgery and mortality revisited: mitigating comorbidity confounding by effect of holidays on surgical timing. *Int Orthop*. 2018;42:1789–1794.
35. Slullitel PA, Lucero CM, Soruco ML, et al. Prolonged social lockdown during COVID-19 pandemic and hip fracture epidemiology. *Int Orthop*. 2020;44:1887–1895.
36. LeBrun DG, Konnaris MA, Ghahramani GC, et al. Hip fracture outcomes during the COVID-19 pandemic: early results from New York. *J Orthop Trauma*. 2020;34:403–410.
37. Pincus D, Ravi B, Wasserstein D, et al. Association between wait time and 30-day mortality in adults undergoing hip fracture surgery. *JAMA*. 2017;318:1994–2003.
38. Minnesota Department of Health. (2021, January 7). *MDH weekly COVID-19 Report 1/7/2021*. Retrieved October 2, 2021, from <https://www.health.state.mn.us/diseases/coronavirus/stats/covidweekly01.pdf>.
39. Brox WT, Roberts KC, Taksali S, et al. The american academy of orthopaedic surgeons evidence-based guideline on management of hip fractures in the elderly. *J Bone Joint Surg Am*. 2015;97:1196–1199.