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Systematic Review

The impact of COVID-19 on the epidemiologic characteristics of traumatic fractures: A systematic review of recent literature

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ABSTRACT

Objective: The aim of this study was to evaluate whether COVID-19-related period of societal restrictions and nationwide in 2020 were associated with a significant change in types and frequency of traumatic fractures.

Methods: A systematic review of recent literature on epidemiologic characteristics of traumatic fractures during the outbreak of COVID-19 was conducted. Multiple databases of PubMed, EMBASE, Cochrane library, and Web of Science were searched, and articles comparing incidence for traumatic fractures before and after of COVID-19 outbreak were included.

Results: From 8 published studies which had been reported from July 2020 to September 2020, a total of 9305 patients were identified. The study period of each study included varied from January 24 to May 22 in 2020. There was a significant decrease in the total number of trauma cases during lockdown by 3229 cases (pre-lockdown n = 6267 and lockdown n = 3038), amounting to a decrease by a pooled percentage of 51.6% ($P = 0.012$). The incidence of hand and tibia fractures decreased while the incidence of femoral fracture significantly increased during COVID-19 outbreak ($P < 0.001$). There was no significant difference in the fracture frequency for all other skeletal areas ($P > 0.05$).

Conclusion: Evidence suggests that there was a significant decrease in the overall number of traumatic fractures during the COVID-19-related period of societal restrictions and lockdown. Proportions of most fractured areas were not significantly influenced by the state of emergency, except for femoral fractures, which had occurred more often during this state. Care must be taken, while developing contingency plans for reallocating resources during the COVID-19 pandemic, not to assume that all trauma presentations will decrease. Evidence from this study has suggested there was a significant decrease in the overall number of traumatic fractures during the COVID-19-related period of societal restrictions and lockdown. Proportions of most fractured areas were not significantly influenced by the state of emergency, except for femoral fractures which had occurred more often during this state.

Level of Evidence: Level III, Diagnostic Study

Introduction

On March 11, the World Health Organization declared a COVID-19 pandemic, and it triggered unprecedented nationwide regulations aimed primarily at slowing the spread of the virus.[1] During the COVID 19 pandemic period, there were changes in the field of health, as in many areas of life, on both employee and patient fronts. The practice of orthopedics was also very affected by the pandemic.[2,3]

Currently, the clinical features of fracture patients are compromised due to the outbreak of COVID-19 in the world. While most of the literature about COVID-19 understandably concentrates on the disease itself, there have been few papers about the incidence of fractures during the pandemic.[4] In addition, the frequency of fractures decreased has been inconsistently reported in previous studies because only patients who applied to one large center in one country were examined.[5] Recently, data from the trauma registry at a regional Level I trauma center indicated that a stay-at-home order during the COVID-19 pandemic was associated with a 70% reduction in the number of traumatic injuries.[6] On the contrary, Williams et al.[7] demonstrated that there was no reduction in levels 1 and 2 trauma presentations at the major trauma centre in 2020 during a legislated period of restriction in sporting activities, gatherings and travel when compared with the same time period 2014–2019. Current evidence regarding trauma frequency during the COVID-19 pandemic relies on a limited number of case studies.[8] Our knowledge about the impact of societal restrictions and lockdown on trauma is confined to a few reviews from single institutions, even though the incidence rates of each fracture may differ between patients of different ethnic backgrounds and nationalities. Analysis of more centers' data of different countries can yield more general and valid results.

The current study was designed to perform a systematic review of the recent literature published about traumatic fracture in order to compare orthopedic fracture frequencies in the pandemic period, when the walk was limited at the home mostly, with those during the same period in the previous year with regular state, thus to examine staying at home as a factor influencing the

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frequency of different fracture types. We hypothesize that the social restrictions placed on the public by the government would reduce the amount of trauma presentations and change the epidemiology of traumatic fractures.

Materials and Methods

Literature search

A systematic review of the available literature using multiple separate search strategies was conducted. The databases of PubMed, Embase, Cochrane Library, and Web of Science were searched using keywords "COVID-19," "corona virus," "fracture," and "trauma" in different combinations with no language or regional restrictions. Several synonyms and different spelling variations for each search term were used in order to capture as many articles as possible. Two independent reviewers separately completed the search, and the results were duplicated two times by each reviewer. The literature search was performed until Sep 30, 2020.

Selection criteria

We aimed to identify all full-text, peer-reviewed publications pertaining to fracture patients under COVID-19 outbreak. The identified articles were assessed for inclusion independently by two authors. Eligibility criterion for inclusion in the review was a specific focus on epidemiologic characteristics of traumatic fractures during the outbreak of coronavirus disease. Relevant articles reporting data on fractures in the form of case series, case control, and cohort studies were included. The exclusion criteria were (1) articles focusing only on the traumatic mechanism (such as fall and car accident),[6,9] (2) articles related to non-orthopedic injuries, (3) studies that had no data on the fracture demographics, and (4) articles without comparative data to assess the incidence of fractures. Limits for the number of patients in each study or the minimum duration of follow-up were not used. Conference papers and letters were excluded as authors felt these did not provide enough detail to allow adequate quality assessment of results and evaluate strength of conclusions. The COVID-19 cohort was then compared with a control group consisting of orthopedic trauma consults received during a non-pandemic time.

Study selection

Literature search and study selection was conducted in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[10] Searching the aforementioned databases yielded a total of 278 articles. A simplified flowchart depicting this process is seen in Figure 1. There were 88 articles that appeared in more than one of the four searches, yielding a total of 190 unique articles. Two reviewers independently screened the titles and abstracts of all studies, and all relevant articles were read in full. Additionally, reference lists of articles were also screened for more relevant papers, and we also hand-searched popular premier orthopedic journals and general medical journals to avoid missing any paper. In cases of disagreement, a consensus was reached through discussion between the two authors.

HIGHLIGHTS

- There was a significant decrease in the overall number of traumatic fractures during the COVID-19-related period of societal restrictions and lockdown.
- The overall frequency of hand and wrist traumas decreased significantly during the COVID-19 pandemic.
- Osteoporotic hip fractures were highly prevalent during this period.

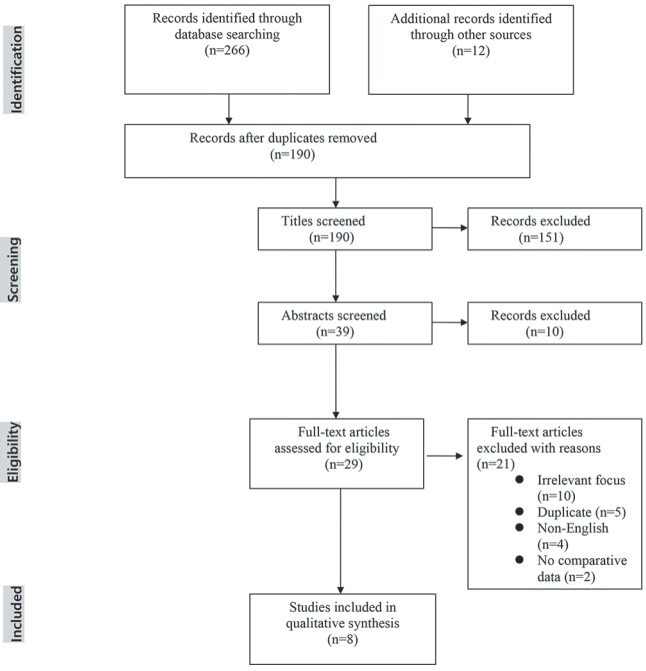

Figure 1. A PRISMA flowchart illustrates the selection of studies included in our systematic review.

Stringent exclusion criteria were applied, leaving eight articles appropriate finally.

Data extraction

A standard data extraction form was used to extract the relevant data from eligible articles. If necessary, we contacted the corresponding authors of the included studies to make sure the information was integrated and to retrieve any missing data. The information extracted was as follows: author, year, country of publication, study period, study design, demographics of the patient sample (age, gender), type of fractures, traumatic mechanism, and the frequency of fractures. As the incidences of fractures were consistent among the trials, we pooled these to derive mean values. All reported fractures were primarily classified into ten groups, regarding anatomical area: clavicle; humerus; forearm including elbow, hand, and wrist; pelvis and acetabulum; femur; patella; tibia; foot and ankle; and spine. We attempted to collect data on compounding factors, which related to causation or mechanism of trauma, for example, fall or motor vehicle accidents. However, due to limited response from data sources, this was left out of the final data analysis. Owing to a lack of prospective randomized studies, most of the larger cohorts giving an answer or at least an insight to fracture patterns were selected for this analysis. There was considerable heterogeneity in data reporting and variability in the methodology of the studies (an I2 value of 75% was indicated according to the test statistic for evaluating heterogeneity); therefore, a formal meta-analysis could not be conducted, and effect sizes could not be calculated. Instead, as the types of fractures and number of patients who were treated for traumatic fractures were consistently reported among the trials, we pooled these to derive mean values.

Statistical analysis

All data were recorded into an Excel spreadsheet (Microsoft Corp, Redmond, WA, USA), and statistical analysis was performed with use of SPSS for Windows (version 24; IBM). Descriptive statistics of the

number of patients, who had been treated for traumatic fractures, was done using frequencies and percentages. Chi-square tests were used to determine any significant differences in categorical variables. Wilcoxon Signed Rank test was used to determine any significant differences between the groups in terms of continuous variables. Statistical analysis was performed by an independent statistician blinded to group allocations. Significance was reported at the 95% confidence level ($P < 0.05$).

Results

Search results and studies included

Our systematic literature review of PubMed, Embase, Cochrane, and Web of Science literature searches revealed a total of 9305 patients from eight selected articles, which have been reported from July to September 2020. Although complete data have not been provided by all the authors, data such as the types and the frequency of fractures were clearly identified in all the reports.

Demography

The patients who were treated for traumatic fractures were included in the present study. Mean age, gender, and characteristic features of each study included have been summarized in Table 1. Two studies[11,12] were reported in China. One multi-center study[12] was included. The number of patients diagnosed with COVID-19 has not been explicitly mentioned by most authors.

The types and frequency of fractures

There was a significant decrease in total trauma numbers during lockdown by 3229 cases (pre-lockdown $n = 6267$ and lockdown $n = 3038$), amounting to a decrease by 51.6% ($P = 0.012$) (Table 2). Significant reduction rates in fracture frequency have been shown in Figure 2.

The incidence of femoral fracture has increased significantly during the COVID-19 outbreak ($P < 0.001$), while the incidences of hand and tibia fractures have decreased ($P < 0.001$ and $P = 0.018$, respectively) (Table 3). Although the absolute numbers of femoral fractures fell by 30.9% from pre-lockdown values, there was a significant increase in the proportion of femoral fractures in the lockdown period (29.59%) compared with pre-lockdown (20.74%) (Table 3), indicating that the absolute volume of osteoporotic hip fractures (which are mostly domestic injuries due to slip and fall at home) remained relatively stable. There was non-significant difference in fracture frequency for all other skeletal areas ($P > 0.05$). The exact types of surgery or numbers of trauma operations performed in the time period were inconsistently reported, making interpretation of these data challenging.

Discussion

The COVID-19 pandemic resulted in unprecedented restrictions of public life in most countries around the world, and many hospital systems experienced dramatic decreases in non-COVID-related patient admissions. Furthermore, many countries in the world are now facing worse second wave of COVID-19 outbreaks, resulting in another lockdown. This systematic review aimed to compare trauma volumes and characteristics of fractures during a state-wide "stay-at-home" order to corresponding historic dates with a pooled analysis of the reported cases.

Reportedly, the overall reduction rate in the number of traumatic injuries during the COVID-19 pandemic varies in the literature between 19% and 70%.[13–17] According to our systematic review, it could be concluded that the total number of orthopedic fractures for surgical treatment was lesser during the COVID-19 social bans in relation to the same period in a year without the bans. Overall, staying home during the COVID-19 pandemic decreased orthopedic trauma frequency of 51.6%. During the nationwide lockdown, the central and all state governments ordered closure of most activities except essential services. As a result of decreased human mobility outside the home in order to

Table 1. Demographic Information in the Study Groups (C, Control Group; P, Pandemic Group; N/A, Not Available)

Author	Journal	Year	Country	Time Interval	C/P	Age	% Male	Level of Evidence
Yu et al.[11]	*Ann Transl Med*	Aug, 2020	China	Jan 24 to Mar 9, 2020	196/112	N/A	N/A	IV
Luceri et al.[4]	*J Orthop Surg Res*	Aug, 2020	Italy	Mar 12 to April 12, 2020	554/330	56.3 ± 23.9	44.3	IV
Hernigou et al.[19]	*Int Orthop*	Aug, 2020	Belgium	Mar 01 to April 15, 2020	109/72	45.5 (1 to 103)	N/A	IV
Lv et al.[12]	*Injury*	Aug, 2020	China	Jan 20 to Feb 19, 2020	1380/776	53.1 ± 23.1	55.8	IV
Mitkovic et al.[16]	*Int Orthop*	July, 2020	Serbia	Mar 20 to May 13, 2020	106/86	63.7 ± 18.1	44	IV
Turgut et al.[18]	*Acta Orthop Traumatol Turc*	July, 2020	Turkey	Mar 16 to May 22, 2020	1744/668	45.2 ± 19.5	54.5	III
Lubbe et al.[5]	*J Orthop Trauma*	Sep, 2020	USA	Mar 17 to April 30, 2020	386/332	44.9 ± 24.0	64.4	III
Maryada et al.[8]	*Indian J Orthop*	Aug, 2020	India	Feb 23 to April 25, 2020	1792/662	N/A	69	IV

Table 2. The Distribution of Fracture Sites in Each Group (C, Control Group; P, Pandemic Group; NA, Not Available, %, Percent Decreased in Pandemic)

	Yu et al.[11]		Luceri et al.[4]		Hernigou et al.[19]		Lv et al.[12]		Mitkovic et al.[16]		Turgut et al.[18]		Lubbe et al.[5]		Maryada et al.[8]		Overall		
Fracture	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	%
Clavicle	NA	NA	13	5	NA	NA	NA	NA	0	1	63	26	52	43	59	12	187	87	53.5
Humerus	28	9	32	33	12	12	130	83	7	3	280	103	45	38	103	36	637	317	50.3
Forearm	28	17	45	14	7	4	149	71	8	6	127	33	51	35	238	103	653	283	56.7
Hand, wrist	3	2	202	73	19	13	NA	NA	1	3	703	243	NA	NA	208	89	1136	423	62.8
Femur	66	51	44	123	37	26	434	296	63	56	87	53	61	63	508	231	1300	899	30.9
Patellar	NA	NA	15	5	NA	NA	137	74	3	2	14	6	6	8	50	16	225	111	50.7
Tibia	40	21	27	12	4	3	289	137	12	10	108	51	104	87	406	102	990	423	57.3
Foot, ankle	7	6	161	59	30	14	NA	NA	10	4	341	146	26	22	156	62	731	313	57.2
Spine	22	6	15	6	NA	NA	203	93	NA	NA	NA	NA	NA	NA	27	7	267	112	58.1
Pelvis	2	0	NA	NA	NA	NA	38	22	2	1	21	7	41	36	37	4	141	70	50.4
Overall	196	112	554	330	109	72	1380	776	106	86	1744	668	386	332	1792	662	6267	3038	51.6

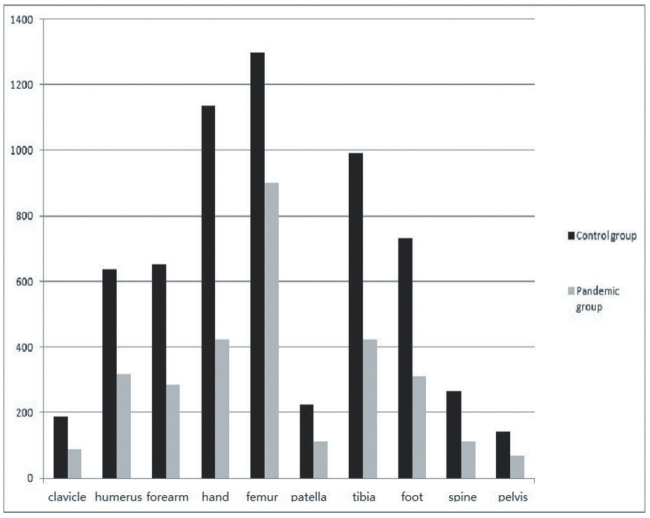

Figure 2. Reduction rates in frequency of each fracture.

Table 3. Percentages of Each Fracture Region Among Pandemic and Pre-Pandemic Time Intervals

Fracture	Control Group (%)	Pandemic Group (%)	*P*
Clavicle	2.98	2.86	0.748
Humerus	10.16	10.43	0.687
Forearm	10.41	9.31	0.097
Hand, wrist	18.12	13.92	*< 0.001*
Femur	20.74	29.59	*< 0.001*
Patellar	3.59	3.65	0.878
Tibia	15.79	13.92	*0.018*
Foot, ankle	11.66	10.30	0.051
Spine	4.26	3.68	0.189
Pelvis	2.24	2.30	0.869
Overall	100	100	

Note: Significant values are in italics.

prevent the spread of the virus, it should not be surprising to predict a decrease in trauma cases. In addition, another reason for this could be that the patients and their families did not want to go to the hospital for minor injuries because they were afraid that they would probably be exposed to COVID 19 infection. Although it is difficult to determine what portion of the decrease in orthopedic trauma is attributable to the shelter-in-place order versus the COVID-19 pandemic in general, data suggest both play a role.[15] With changes in life style and more people working from home, there may be a reduction in overall injuries in future. For the time being, in case similar public restrictions are ordered, the spared medical resources could be deployed to other clinical areas. One thing that should be noted is the fact that there are several studies[18,19] investigating the fractures in both pediatric and adult populations. Fracture epidemiology in children is rapidly changing during the COVID-19 pandemic, with a nearly 60% reduction in total fracture volume compared with prior years,[20] and it may show a different pattern compared to the adult form. Children during the pandemic were more frequently injured on body-powered vehicles such as bicycles and during a high-energy including trampolines.[20] Turgut et al.[18] demonstrated that finger fractures in pediatric patients and metatarsal fractures in adult patients were found to have significantly decreased during the pandemic. We believe that further multicenter studies are needed to demonstrate objective epidemiological pattern of pediatric trauma separately in COVID-19 outbreak.

Nevertheless, undoubtedly, traumatic injuries will continue to occur during the COVID-19 pandemic, and fractures still need to be treated. Despite attempts at reduction, there remains a substantial demand on orthopedic and trauma care because of the special nature of our services. However, it is uncertain to what extent. With regard to hand and upper limb trauma, there have been contradictory reports in the literature. Pichard et al.[21] demonstrated that they observed a two-third decrease in the rate of upper limb emergencies (−64.9%) in France. On the contrary, Andrea et al.[22] reported that even during drastic movement restrictions and the prolonged suspension of work and leisure activities secondary to COVID-19 epidemic in 2020, hand and wrist traumas rate remained almost the same compared to the same period of the previous year. This is probably due to the fact that even though sport and traffic-related hand traumas decreased, accidental work-related in the adults and domestic hurts in the elderly were still prevalent. Changes in trauma volume and patterns may be highly individualized and influenced by geography, patient population, and other factors.[13] According to our pooled analysis, the quarantine act restrictions caused a drastic decline in the incidence of minor trauma, and consequently, the overall frequency of hand and wrist traumas decreased significantly during the COVID-19 pandemic ($P < 0.001$). Similarly, the reduction in lower limb fractures in the present study may be caused by the cessation of organized sports or outdoor sporting activities, as it has been reported that majority of traumatic injuries located in the lower extremity are related to football or soccer, for instance.[23]

The results of our study demonstrated that COVID-19 pandemic has definitely impacted the epidemiology of hip fractures after lockdown. While most traumatological presentations decreased in frequency over the course of the outbreak, proportions of femoral fractures increased rather than decreased during this state. Not surprisingly, because hip fractures often occur indoors, in the garden, and within the property, the elderly people who ordinarily stay at home are more likely to have low-energy fractures (fall from standing height and fall from a low height) putatively due to the decrease in outdoor exercise and more sedentary lifestyle during the epidemic period.[24] Therefore, compared with the non-epidemic period, the proportion of osteoporotic fracture in this age group has increased significantly.[12] It has been already reported that the number of osteoporotic hip fractures remained stable during the social restrictions.[25–28] Yu et al.[11] demonstrated that the incidence of hip fractures among the elderly has increased during the COVID-19 epidemic. It seems that low energy and fragility trauma will persist whilst injuries associated with younger people have reduced.[29] Contingency plans in times of crisis need to be carefully targeted, and to keep in mind certain public health issues that do not decrease, despite a state of emergency. This epidemiological shift of hip fracture is also associated with higher mortality rate.[30] Therefore, more attention should be paid to the prevention of osteoporosis fracture in the elderly during the epidemic period. As it generally requires prolonged medical interventions to limit the risks of impaired skeletal integrity and the onset of fractures,[31] timely supplement calcium agent, supplement active vitamin D3 to promote the absorption and utilization of calcium, and appropriated anti-osteoporosis medication should be actively taken during the epidemic period.[12] Further studies are needed to assess the effects of the COVID-19 pandemic on orthopedics so that methods to effectively care for patients can be created and implemented.

The strength of this study lies in being able to compare orthopedic fracture frequencies in the pandemic period with those during the

same period in the previous year with regular state. We believe that our study has provided more general and valid results through analysis of multiple centers' data of different countries.

There are several limitations in our study that ought to be considered. First, all included studies were retrospective case series in nature, providing lower quality evidence and rendering reporting bias unavoidable. In addition, it should be noted that the lockdown process of every country was different. Our study was not appropriate for meta-analysis due to the fact that there were different ways of restrictions in different times in different countries. Therefore, to reduce bias as much as possible in our systematic review, we established strict selection criteria and included studies with a comparative analysis. Second, although we utilized a systematic methodology that we believe could be reproducible, it may be possible that different search terms and data sources would have provided additional studies that could have met selection criteria. We had hoped for a larger number of trials to improve the external validity of our findings.

Based on this systematic review, societal restrictions and lockdown during the coronavirus pandemic have had a significant impact on the volume and nature of traumatic fractures. While most traumatological presentations decreased in frequency over the course of the outbreak, osteoporotic hip fractures were highly prevalent during this epidemic. Our study shows the need for attention to safety in the elderly population and taking precautions at homes. In addition, orthopedic surgeons must plan for the future lifting of social restrictions and a possible associated increase in traumatic presentations. Additional multicenter studies with involvement of larger number of trauma patients to include a wide range of ethnic backgrounds will help improve our ability to prepare a better-informed response toward the COVID-19 pandemic.

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