ISSN: 2690 - 9189

Research Article

International Journal of Orthopaedics Research

Seasonal Trends in Operative Pediatric Supracondylar Humerus and Femoral Shaft Fractures at a Pediatric Level 1 Trauma Center

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Submitted: 16 July 2021; **Accepted:** 23 July 2021; **Published:** 30 July 2021

Citation: *Tyler Tetreault, Amrita Mahajan, Christina E Howell, Lori J Silveira and Julia S Sanders (2021) Seasonal Trends in Operative Pediatric Supracondylar Humerus and Femoral Shaft Fractures at a Pediatric Level 1 Trauma Center. Int J Ortho Res, 4(2): 69-72.*

Abstract

Background: *Supracondylar humerus (SCHF) and femoral shaft (FSF) fractures are two common injuries at pediatric trauma centers. While anecdotally we see an increase in injuries with warmer weather, the purpose of this study was to objectively describe the seasonal variation in these operative fractures, and their relative burden on hospital census.*

Methods: *We performed an IRB-approved, retrospective review of 1626 SCHF and 601 FSF treated operatively from 2013-2018 at a single level 1 pediatric trauma center. Dates of injury were categorized with hospital census information, and temperature and precipitation data were obtained through the National Weather Service.*

Results: *For every 10° F increase in temperature, there was a 5% increased likelihood of FSF (p=0.048) and a 26% increased likelihood of SCHF (p=<0.0001). FSF were less likely to occur on weekdays than weekends (OR 0.59, p<0.0001) and less likely to occur on days with precipitation (OR 0.41, p= 0.03). SCHF demonstrated no significant weekly or precipitation-related trends. SCHF represent a significantly larger burden on orthopedic volume during summer months. The ratio of operative FSF relative to the total orthopedic volume per month did not correlate with season.*

Conclusions: *As often anecdotally reported, SCHF volumes mirror temperature variations annually. FSF appear to have more complex trends, with increased incidence on weekends regardless of season. Geographic variation in weather contributes strongly to pediatric trauma volume, and the ability to forecast a hospital system's operative fracture volume allows for responsible resource allocation during key periods.*

Level of Evidence: *Retrospective case series, Level IV*

Introduction

Two of the most common injuries managed by pediatric trauma centers are supracondylar humerus (SCHF) and femoral shaft (FSF) fractures [1-4]. The relationship between weather and pediatric orthopedic trauma volume has been a topic of speculation. Anecdotally, an increase in injuries can be appreciated with warmer weather. In the adult population, orthopedic consult volumes have been noted to increase with increasing average daily temperature [5].

Internationally, an increase in pediatric SCHF cases on drier and warmer days has been noted [5]. Similarly, there is some data showing an increase in children's wrist and forearm fractures during spring and summer and a lower incidence during the winter [7]. Children injured in the warmer months were also more likely to require admission to the hospital [8]. Contrary to our experience, data from Israel describes a higher fracture rate during the school year compared to time periods during summer vacation [10].

Despite being a topic of great interest, there have been no studies in the United States evaluating the relationship between daily weather and precipitation patterns with pediatric SCHF and FSF. Factors such as school schedules and variations in regional weather create difficulties with generalizability of data in such a large country. Given the large relative burden of trauma on orthopedic admissions, further understanding of seasonal trends in pediatric orthopedic injuries at a tertiary care center in a large metro area with multiple seasons can provide valuable information to develop strategies for more efficient resource allocation at pediatric trauma centers.

The purpose of this study was to describe the seasonal variation in the incidence of operative pediatric SCHF and FSF, and the relative burden of these injuries on hospital census. Based on anecdotal experience, we hypothesized that the incidence of pediatric SCHF would increase during the summer and pediatric FSF would increase during winter months, with these injuries contributing a relatively large percentage of operative and admission volume during these peak seasons.

Materials and Methods

Approval was obtained from the Colorado Multiple Institutional Review Board for this retrospective study. Electronic medical records were reviewed to identify all patients under 18 years of age with SCHF or FSF requiring operative intervention from 2013 through 2018. Medical records and radiographs of these patients were reviewed and those undergoing revision surgery, with a pathologic fracture, or with history of previous fracture to the same bone were excluded. A total of 1626 patients with SCHF and 601 with FSF were identified.

Demographic and injury characteristics were reviewed for all patients included in the study. This included age, sex, date of injury, date of surgery, and surgery performed. The total duration between injury and surgery were noted for all study patients. Those with delayed presentation (>1 week), pathologic fractures, recurrent fractures, and injury location outside of the Denver metropolitan area were excluded. Initial radiographs were reviewed to verify fracture type.

Daily maximum and minimum temperatures and occurrence of precipitation in the Denver metro region were collected from the online database Climate Data Online (https://www.ncdc.noaa.gov/cdo-web/) [11]. Children's Hospital Colorado operative volume, admission volume, and orthopedics department census was gathered from 2013 through 2018 through the EPIC database.

A time series analysis was performed from the monthly proportion of SCHF and FSF surgeries to the total number of orthopedics procedures over a six-year period. Two indicator variables were constructed to identify whether any SCHF or FSF surgeries were performed on a given day and separate logistic regression models were developed to examine the relationship between days when SCHF or FSF occurred and the covariates of interest: maximum daily temperature, daily precipitation and an indicator variable which identified whether the injury happened on the weekend or weekday. Poisson models using the R package "season" to examine the effect of seasonality on the proportion of SCHF and FSF to all monthly orthopedics surgeries. The model was adjusted by including two offset terms accounting for the unequal days in a month and total volume of surgeries per month. All results were considered significant at P-value<0.05. All analyses were performed in R version 3.6.1(2019-07-05).

Results

From 2013 to 2018 a total of 1626 operative SCHF were treated at our level 1 pediatric trauma center. The average age at time of injury was 6.3 +/- 2.7 years (range 0-17 years) Of the treated patients, 821 (50.5%) were girls and 805 (49.5%) boys. Over the same time period 601 FSF including 175 (29.1%) girls and 426 (70.9%) boys underwent surgical treatment. The average age was 7.4+/- 4.8 years (range 0-17 years). 337 SCHF and 77 FSF were excluded from this study due to incorrect diagnosis codes, injury outside the Denver metro area, pathologic fracture or associated metabolic bone disorder, repeat fracture, or delayed presentation.

The Effect of Temperature on Fracture Incidence

There was a significant correlation between temperature and the incidence of SCHF and FSF. The likelihood of sustaining a SCHF increased by 26% for every 10-degree increase in daily maximum temperature (OR 1.026, p<0.0001). The likelihood of sustaining a FSF increased by 5% for every 10-degree increase in daily maximum temperature (OR 1.005, p=0.048) (Figure 1).

Figure 1: Average Monthly Temperature and Operative Fracture Volume 2013-2018

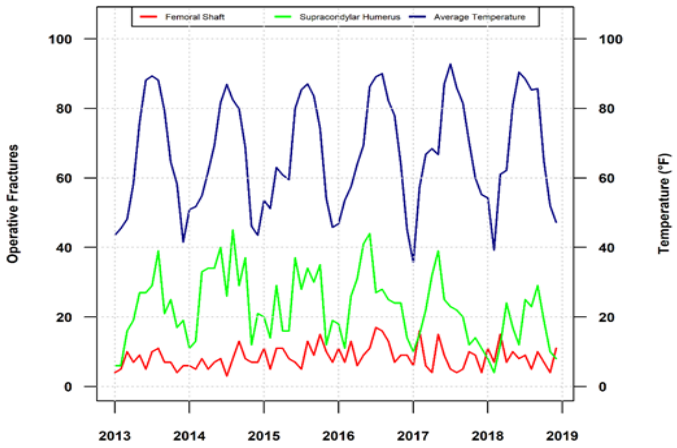

Figure 1: Operative supracondylar humerus and femur fracture incidence and average monthly temperature.

The Effect of Precipitation on Fracture Incidence

The likelihood of sustaining a SCHF did not correlate significantly with the presence or absence of precipitation (OR 0.81, p=0.26). The likelihood of FSF decreased (OR 0.41, p=0.03) in the presence of precipitation.

Weekly and Seasonal Trends

SCHF did not show any weekly trends and were just as likely to occur on weekdays compared to weekends (OR 1.1, p=0.18). FSF were less likely to occur on weekdays compared to weekends (OR 0.59, p<0.0001).

The ratio of SCHF procedures relative to the total number of orthopedic procedures per month also significantly correlate with the season. As shown in the Poisson model [Figure 2], there is a significantly greater burden of SCHF from March through October. The rate ratio peaks in May, demonstrating that the rate of SCHF relative to all orthopedic procedures is twice as great as compared to January.

A Poisson analysis of FSF shows that there is no significant change in the rate ratio for operative FSF by month (Figure 3).

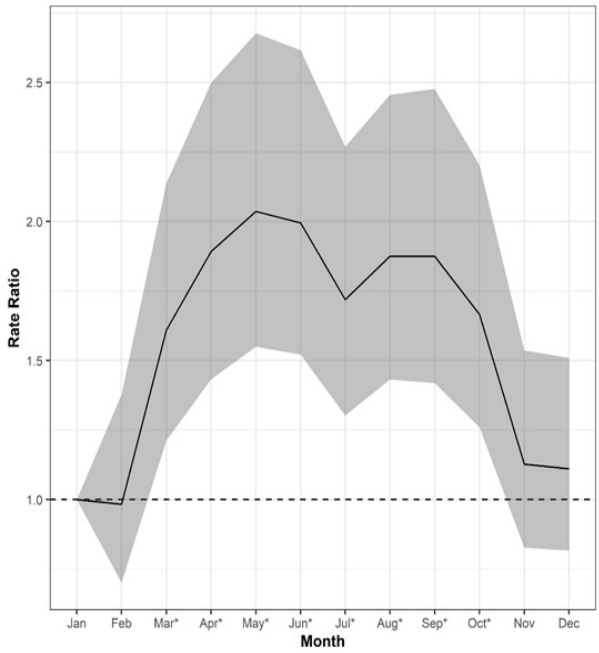

Figure 2: Mean monthly rates of supracondylar humerus fractures compared to the referent group (January) over a 6-year period.

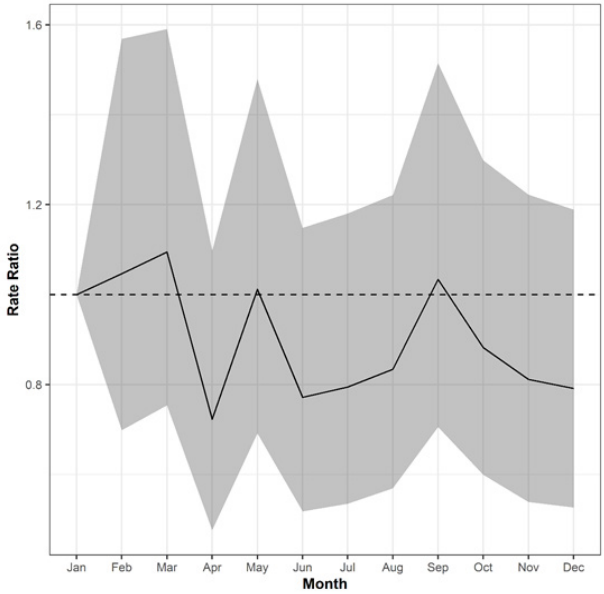

Figure 3: Mean monthly rates of femur fractures compared to the referent group (January) over a 6-year period.

Discussion

In concordance with our hypothesis, our results support the anecdotal evidence that the incidence of SCHF correlates with higher temperature, and represent a higher burden on the orthopedic service during the summer months. However, we found no association between SCHF rate and presence of precipitation or day of the week.

Contrary to our expectations, we noted an increase in FSF with warmer temperatures, not with cooler weather. FSF are less likely to occur on weekdays or days with precipitation. FSF represent a more stable burden of fracture volume throughout the year, with less variation than SCHF.

Our data supports patterns noted in other global regions. A study in Finland showed that SCHF have a positive correlation between temperature and fracture incidence with risk 2.6 times greater in warm weather (15-24.9 degrees Celsius) rather than cooler weather (<15 degrees Celsius). Additionally, risk of fracture was 3.5 times greater during dry weather.6 In our study, we saw no such correlation with precipitation and the incidence of SCHF. It is possible that, in certain regions, outdoor activities are more tolerable in wet weather, and therefore fracture incidence does not correlate with precipitation.

In Israel, investigators found that the overall fracture rate is highest during warm seasons with nadirs during the extreme temperatures of summer and winter. The rate of fracture was significantly higher on school days compared to summer holidays.10 This trend was thought to reflect children living a more sedentary lifestyle during the summer vacation, due to fewer structured activities and hotter outdoor temperatures. Others also found that hotter temperatures (>25 degrees Celsius) decreased the risk for fracture, which was attributed to children avoiding more strenuous activities in order to stay cool.6 This trend was also witnessed in Boston, where pediatric trauma consults and admissions peaked in warm, dry weather on non-school days with a lower incidence during July and August.8 While our study did not find a significantly lower rate of fractures during the summer months, the peak incidence of SCHF occurred in May rather than at the peak of summer, suggesting a trend towards an increased incidence of fracture in months with less extreme heat.

The effect of school participation on fracture incidence remains poorly understood. While some studies have noted a positive correlation between school days and fracture incidence, others have found the opposite to be true.8,9 We found that day of the week has no significant correlation with the incidence of SCHF, but FSF are more likely to occur on weekends. These findings likely reflect regional differences in pediatric outdoor and recreational activities.

While SCHF and pediatric FSF account for a large portion of orthopedic injuries, this cohort certainly does not capture all pediatric trauma. As such, caution must be taken when extrapolating these trends to other injury types. In addition, the weather trends and outdoors access in the Mountain West may significantly differ from other parts of the country. Our findings here may not be reflected in other regions of the United States, or in other parts of the world.

Our weather data was gathered from a national weather database using a single representative location. While the majority of injuries occurred in a large metro area that has a homogenous weather distribution, it is not unusual to receive patients transferred from the mountain region or neighboring states. If the injury was known to occur outside of the Denver Metro area, these patients were excluded from our analysis. However, given the retrospective nature of our study, it was not always possible to identify the exact location of injury. In these instances, the location of injury is a poten-

tial confounding factor.

In these instances, the location of injury is a potential confounding factor. While this study may reflect what is accepted as commonplace knowledge regarding SCHF, quantifying the magnitude of this injury trend and subsequent operative burden is crucial to effective resource allocation. Understanding the relative constant nature of FSF similarly allows for department-level planning. The ability to forecast a hospital system's urgent trauma surgery volume allows for responsible preparation in terms of staff and operating room availability. Ultimately, such a system can theoretically improve patient care by shortening the time to surgery for these patients and decrease cost by improving resource utilization.

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