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# Isolated traumatic orbital floor fracture: An analysis of the National Trauma Data Bank

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## Abstract

**Objectives:** To date, no study provides a comprehensive analysis of traumatic orbital floor fractures across the United States. We aimed to characterize patient demographics, injury-related variables, and operative management in this population.

**Method:** The National Trauma Data Bank was queried for open or closed orbital floor fractures from 2008 to 2016. Clinical data were extracted.

**Results:** Overall, 148,592 orbital floor fractures were identified, with 142,577 (95.9%) closed- and 6158 (4.1%) open-type fractures. A total of 106,243 (71.5%) patients were male and the median patient age was 41 years. The majority of patients (79.2%) had abbreviated injury scale scores of ≤2, indicating minor/moderate injury. Fracture mechanism of injury (MOI) differed by gender, with the most frequent being unarmed fights in men (34.3%) and falls in women (14.0%). There were 29,600 patients (19.9%) with isolated orbital floor (I-OF) fractures. The MOI most strongly associated with operative intervention of with I-OF fractures were penetrating injuries caused by a firearm (*odds ratio* [OR]: 2.91; 95% *confidence interval* [*CI*]: 1.62–5.20) and cuttings/piercings (*OR*: 2.17; 95% *CI*: 1.29–3.65).

**Conclusion:** This large epidemiological study reveals that orbital floor fractures tend to present with minor or moderate injuries and are more likely to require operative intervention in setting of firearm or cut/pierce injuries.

KEYWORDS

epidemiology, National Trauma Data Bank, orbital fracture, risk factors, trauma

## Key points

- **Significant findings:** Isolated orbital fractures due to penetrating firearm or cut/pierce injuries are more likely to require surgical repair, while those resulting from a fall or as a passenger in a motor vehicle accident are less likely to need surgical repair.
- **What this study adds:** This is the first study to provide a comprehensive analysis of traumatic orbital floor fractures across the United States. We also present a

secondary analysis of the predictors of surgical intervention in patients with isolated orbital floor fractures.

## INTRODUCTION

Orbital floor fractures can present in isolation ("blow-out fracture") or along with other fractures of the midface and zygomaticomaxillary complex (ZMC). Collectively these fractures are estimated to account for 25% of all traumatic facial fractures.[1–5] While many orbital fractures can be managed conservatively without surgical intervention, 11%–15% are associated with ophthalmological emergencies, requiring urgent operative intervention.[6,7] Of the seven facial bones comprising the orbit, those of the medial wall and floor are quite delicate and prone to fracture.[8,9] As such, large orbital floor fractures commonly present with herniation of orbital contents into the maxillary sinus, leading to associated enophthalmos and diplopia.[10–13] Small or hairline floor fractures can result in restriction of extraocular movement due to entrapment of the inferior rectus or adjacent periorbital soft tissue, as well as associated traumatic optic neuropathy, and diplopia.[10–13] The potential for these and other related consequences obviate the need for a comprehensive understanding of the epidemiology of orbital floor fractures, their workup, and their management.

Although the general principles of orbital trauma management are well established, prior clinical guidance is currently being re-examined.[11] This is warranted given recent advancements in computed tomography imaging,[14] endoscopic sinus approaches,[15] and new data specifying surgical indications and optimal timing.[16] Despite this need for re-examination, no large-scale study has characterized the epidemiology and management of traumatic orbital floor fractures. To address this paucity in the literature,a systematic analysis of the National Trauma Data Bank (NTDB) was undertaken. We aimed to: (1) characterize clinical, demographic, and injury-related variables in patients presenting with traumatic orbital floor fractures; (2) identify procedures performed and predictors of clinical outcomes in patients with isolated orbital floor (I-OF) fractures.

## MATERIALS AND METHODS

The NTDB is the largest nationwide incident-based trauma repository. Created by the American College of Surgeons, it comprises more than 8 million records and pulls data from over 750 trauma centers across the United States.[17] For this study, the NTDB was queried for all adult patients presenting to an NTDB-participating trauma center between 2008 and 2016. Data were extracted using the International Classification of Diseases, Ninth Revision (ICD9) diagnostic codes referring to "Fracture orbital floor, closed" (802.6) and "Fracture orbital floor, open" (802.7). Baseline patient characteristics were collected, including age, sex, race, and concomitant injuries on admission. Relevant clinical data were abstracted from each record: mechanism of injury (MOI), diagnoses, procedures performed, abbreviated injury scale (AIS) score, Glasgow Coma Scale (GCS) score, and trauma center level. We further analyzed the likelihood of surgical intervention by MOI in patients with I-OF fractures. Such fractures were defined as involving only the orbital floor, without additional fractures of the internal orbital skeleton, nasal, maxilla, mandible, or other facial bone.

With regard to scoring, AIS is a consensus-derived, global severity scoring system that classifies individual injuries by specific anatomical region on a 6-point severity scale (1 = *minor*, 2 = *moderate*, 3 = *serious*, 4 = *severe*, 5 = *critical*, 6 = *maximum*).[18] According to the AIS dictionary, coding of all injuries to the facial region should begin at 2 points in severity (moderate). Those injuries involving the orbit, therefore, have a minimum AIS score of 2, by definition. Furthermore, GCS is a neurological assessment that objectively describes the extent of impaired consciousness.[19] This scale assesses patients on three aspects of responsiveness: eye-opening, motor, and verbal responses. Scores range from 3 to 15, with a classification of traumatic brain injuries being reported as severe (GCS ≤ 8), moderate (GCS 9–12), or mild (GCS ≥ 13).

Consistent with nomenclature of fractures outside of the orbit, fractures of the orbital floor can be classified as open or closed. "Open" orbital floor fractures are those in which bone of the orbital skeleton protrudes though the skin or is visualized though a deep wound. "Closed" orbital floor fractures are limited to the internal orbital skeleton such that the skin remains intact with no externally visible bone. Both are considered "blow-out" fractures.

Collected data were summarized via SAS (SAS Analytics Software) and Excel, and forest plots with risk ratios were generated in Stata version v15.1 (StataCorp). This study was deemed exempt by the Institutional Review Board of the University of Pennsylvania given the deidentified, publicly accessible data set utilized.

## RESULTS

### Baseline characteristics

Between 2008 and 2016, a total of 148,592 patients were admitted to trauma centers for orbital floor fracture injuries, including 142,577 (95.9%) open and 6158 (4.1%) closed fractures. A total of 106,243 (71.5%) patients were male and 100,300 (67.5%) patients were white. Median age was 41 years (interquartile range: 25–57 years). Patients most commonly presented to Level I or Level II trauma centers, representing 67.1% and 29.5% of cases, respectively, in which trauma center level was known. The majority of recorded AIS scores were ≤2 (*n* = 40,434; 79.3%), indicating minor (14,014) or moderate (26,420) injury. There were only 516 (1.0%) recorded incidents of severe, critical, or maximal/fatal injuries (AIS ≥ 4). Consistent with these relatively minor AIS scores, over 75% presented with GCS scores ≥13, suggestive of only mild head injury. Full cohort demographic information can be found in Table 1.

## Mechanism of injury

When recorded (*n* = 49,871), the most common type of injury resulting in orbital floor fracture was assault (*n* = 28,942; 58.0%). Less common causes were falls and motor vehicle trauma (MVT) (25.9% and 16.1%, respectively) (Figure 1). Mechanisms of traumatic injury differed by gender. For men, the assault-type MOIs were most frequent: unarmed fights/brawls (47.4%) and attacks via blunt/thrown object (22.8%). Falls were less frequent among male patients (14.1%). In contrast, the most common MOIs by far in women were falls (58.5%), followed by MVT (17.2%) and unarmed fights/brawls (17.1%).

## Outcomes among I-OF fractures

Of all patients with orbital floor fractures, a total of 29,600 (19.9%) occurred in isolation without concomitant facial fractures. Only 512 (1.7%) of these I-OF fractures required operative intervention during initial hospitalization. Penetrating injuries resulting in I-OF fractures were significantly more likely to require surgical repair of the orbit than blunt force traumas (*odds ratio* [*OR*]: 2.54; 95% *confidence interval* [*CI*]: 1.69–3.84) (Figure 2). Of those penetrating injuries causing I-OF fractures, the MOIs most strongly associated with operative intervention were firearm injuries (*OR*: 2.91; 95% *CI*: 1.62–5.20), cut/pierce injuries (*OR*: 2.17; 95% *CI*: 1.29–3.65), and injuries in which patients were struck by/against an object (*OR*: 1.94; 95% *CI*: 1.63–2.31). Patients significantly less likely to undergo operative repair while hospitalized were those who sustained I-OF fractures due to a fall or as a passenger in a motor vehicle accident (MVA). Moreover, designated injury intent was also predictive of the need for operative repair in the setting of I-OF fractures. Victims of assault were more likely to need surgery (*OR*: 1.64; 95% *CI*: 1.38–1.96), while unintentional or accidental I-OF fractures were less so (*OR*: 0.62; 95% *CI*: 0.52–0.74).

# DISCUSSION

Orbital floor fractures are major contributors to the burden of facial fractures in the United States.[1–3] To date, however, there remain no uniform recommendations for surgical intervention on these fractures.[20] Using the NTDB, we conducted an analysis of all adult patients presenting with I-OF fractures between 2008 and 2016.

The demographics in our study closely resemble the prior literature onnasal,[21] facial,[22] and orbital floor fractures[23] in regards to a relatively young patient age and strong male predilection. As

**TABLE 1** Demographics and clinical presentation of patients with orbital floor fractures (*n* = 148,592).

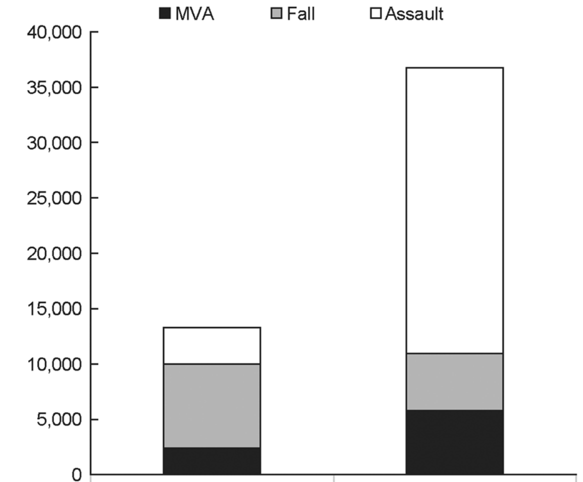
| Characteristic | Data |
|---|---|
| Age [year, median (IQR)] | 41 (25–57) |
| Gender [*n* (%)] | |
| Male | 106,283 (71.5) |
| Female | 42,158 (28.4) |
| Unknown | 151 (0.1) |
| Race [*n* (%)] | |
| American Indian | 1548 (1.0) |
| Asian | 2670 (1.8) |
| Black or African-American | 22,699 (15.3) |
| Native Hawaiian/Pacific Islander | 337 (0.2) |
| White | 100,272 (67.5) |
| Unknown/other | 21,066 (14.2) |
| Orbital fracture [*n* (%)] | |
| Open | 142,577 (96.0) |
| Closed | 6158 (4.0) |
| Trauma center level [*n* (%)] | |
| I | 61,083 (41.1) |
| II | 26,843 (18.0) |
| III | 2938 (2.0) |
| IV | 126 (0.1) |
| N/A | 57,602 (38.8) |
| Common concomitant injuries [*n* (%)] | |
| Closed malar/maxillary fracture | 69,251 (46.6) |
| Closed nasal bone fracture | 49,331 (33.2) |
| Closed facial bone fracture | 47,967 (32.3) |
| AIS score [*n* (%)] | |
| 1–2 | 40,434 (27.1) |
| 3–4 | 10,504 (7.1) |
| 5–6 | 81 (0.1) |
| Unknown | 97,573 (65.7) |
| GCS score [*n* (%)] | |
| 3 | 7282 (4.9) |
| 4–5 | 1590 (1.1) |
| 6–8 | 4471 (3.0) |
| 9–12 | 7124 (4.8) |
| 13–15 | 64,266 (43.2) |
| Unknown | 63,859 (43.0) |

Abbreviations: AIS, abbreviated injury score; GCS, Glasgow Coma Scale; IQR, interquartile range.

such, the median sample age was 41 years and 71.5% of patients were male. It is known that facial fractures caused by assault tend to be most common among young males.[24–26] Although both the events and clinical manifestations surrounding orbital fractures can be diverse, the preponderance of assault cases in the NTDB sample may help explain the male over representation. Indeed, regardless of gender, the overall top MOI for orbital fractures was assault (58.0%). The majority of these assaults were observed in males (88.9%) (Figure 1). Similarly, a recent case series (*n* = 156) by Prabhu et al.[16] found the most common injury mechanism for I-OF fracture to be assault, albeit at a lower reported prevalence (34.7%).

While orbital floor fractures are commonly seen in clinical practice, the mechanism of fracture is poorly understood. The two pathophysiological theories explaining these fractures are the hydraulic and buckling theory, which implicate trauma to the orbital rim and the globe, respectively. Under the hydraulic theory, a blow force to the globe in the setting of lower-impact injuries is transmitted to the weaker orbital floor while leaving the ZMC intact.[16,27] Our results are congruent with this pattern of injury given that I-OF fractures were most commonly caused by assault (low-impact) and less frequently by MVA (high-impact). Such fractures of the orbital floor occurring in isolation made up to 20% of all orbital fractures. This proportion is consistent with other recent reports.[5,26]

With regards to surgical intervention, prior studies describe surgery as being more common among orbital fractures caused by MVA (35.0%) than those due to assault or fall (21.9% and 13.4%, respectively).[25] In contrast, we report that operative interventions on I-OF fractures were most common in the assault category, which included injuries from firearms, cuttings/piercings, and those resulting from a strike by/against an object. These three MOIs were each statistically significant predictors of the need for surgical intervention (Figure 2).




| | Female | Male |
|---|---|---|
| Assault | 3,214 | 25,728 |
| Fall | 7,736 | 5,183 |
| MVA | 2,270 | 5,740 |

**FIGURE 1** Most common mechanisms of injury for orbital floor fracture by sex (*n* = 49,871). MVA, motor vehicle accident.

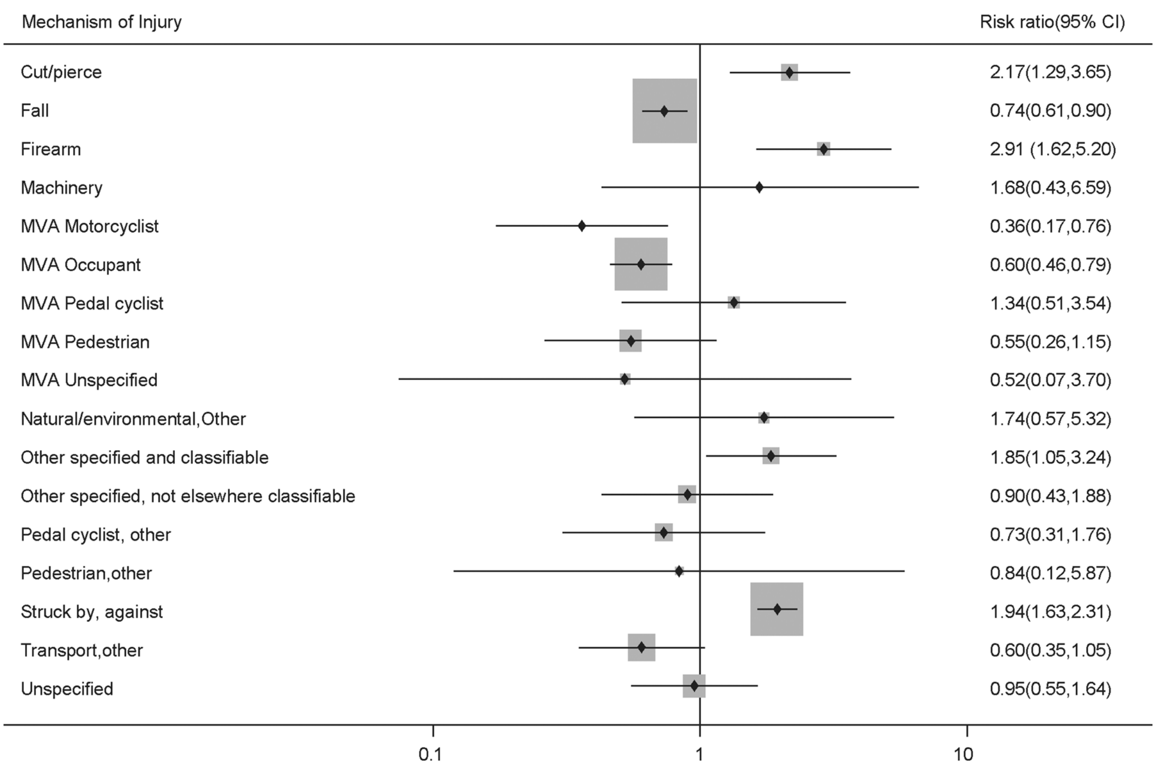



**FIGURE 2** Forest plot demonstrating risk ratio of operative intervention by a mechanism of injury for orbital floor fracture. CI, confidence interval; MVA, motor vehicle accident.

Taken together, complex orbital fractures can be the result of significant trauma and thus frequently associated with serious injuries, including intracranial[28–31] and intraocular injury.[20,32] Conversely, we report that the majority of I-OF fractures present with the mildest form of intracranial injury (GCS ≥ 13, 75.8%) and only minor/moderate regional injuries (AIS ≤ 2, 79.3%). Although the AIS dictionary specifies that coding of all injuries to the facial region should begin at 2 points in severity (moderate), this scoring rule was not routinely followed in clinical practice. A total of 14,014 orbital floor fracture injuries (9.4%) received an AIS score of 1. This indicates that either there is room for improvement in score reporting, or that a subset of these fractures tend to be perceived as relatively minor in severity based on the clinical experience of providers responding to such trauma calls.

A limitation of this report is that the NTDB includes only operations on indexed hospitalizations. The NTDB does not include follow-up information on subsequent operative interventions undertaken on an outpatient basis.[33] For this reason, our results could underestimate the rate of operative intervention, some of which may occur more than a month after injury.[14] Likewise, we are unable to comment on long-term functional or cosmetic complications. Another inherent weakness of NTDB is that it does not include outpatient evaluations, emergency department visits, and other non-trauma activations. Injury severity may, therefore, be overestimated due to not capturing potentially less severe orbital floor fractures that do not warrant hospitalization. Nevertheless, this study does represent an important addition to the literature as it describes the epidemiology and risk factors associated with isolated fractures of the orbital floor in patients presenting to trauma centers across the country. Our findings are highly generalizable and potentially of interest to surgeons from a variety of subspecialties involved in the care of ocular trauma (i.e., emergency medicine, trauma surgery, ophthalmology, otolaryngology, and oral and maxillofacial surgery).

## CONCLUSIONS

The present study is the largest epidemiological study on traumatic orbital floor fractures to date. Importantly, we report that I-OF fractures tend to be conservatively managed, with only 1.7% requiring operative repair. We also demonstrate that patients presenting with assault-type injuries (cut/pierce, firearm, or struck by/against an object) were significantly more likely to require operative intervention for I-OF fractures. Individuals who sustained I-OF fractures due to a fall or as a passenger in an MVA were significantly less likely to require operative repair. Careful consideration should be given to the mechanism of a patient's injury, in addition to the physical exam, in personalizing operative management of patients presenting with traumatic orbital floor fractures. Future multi-institutional prospective studies should investigate long-term functional and cosmetic outcomes not assessed in this report.

### AUTHOR CONTRIBUTIONS

**Emma De Ravin**: Conceptualization (lead), methodology (lead), visualization (lead), writing—original draft preparation (lead), writing—reviewing and editing (lead); **Katherine Xu**: Data curation (lead), software (lead), conceptualization (equal), methodology (equal), writing—reviewing and editing (supporting); **Christian Fritz**: Writing—original draft preparation (lead), writing—reviewing and editing (supporting), investigation (supporting), conceptualization (supporting); **Harman S. Parhar**: Supervision (supporting), conceptualization (supporting), visualization (supporting), writing—reviewing and editing (supporting); **Karthik Rajasekaran**: Supervision (lead), conceptualization (lead), methodology (supporting), validation (lead), writing- reviewing and editing (lead).

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### CONFLICT OF INTEREST STATEMENT

Professor Karthik Rajasekaran is a member of World Journal of Otorhinolaryngology—Head & Neck Surgery (WJOHNS) editorial board and is not involved in the peer review process of this article. The authors declare no conflicts of interest.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### ETHICS STATEMENT

This study was performed in compliance with the Helsinki Declaration.

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