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# Orbital floor fractures in Taiwan: A 10-year nationwide population-based study

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**Abstract:**

**PURPOSE:** To characterize the epidemiology, associated complications, and risk factors of orbital floor fractures in a nationwide longitudinal health insurance database.

**MATERIALS AND METHODS:** Claims data from a million randomly selected registered residents from the Taiwan National Health Insurance Research Database were analyzed between 2001 and 2011 as part of a retrospective cohort review. Patients were identified using the International Classification of Disease-9 diagnosis codes for orbital floor fracture (closed: 802.6; open: 802.7). The cases were categorized as surgical or nonsurgical based on the procedure codes and compared statistically.

**RESULTS:** From 2001 to 2011, 663 patients were diagnosed with orbital floor fractures out of a total population at risk of 9,836,431 person-years (average incidence: 6.78 persons/100,000/year) with overall increasing incidence. Surgical treatments were performed in 213 (32%) patients. Patients who received surgical treatment were younger than those who did not (mean age 25.3 ± 13.6 years vs. 34.2 ± 18.6 years, $P < 0.001$). The diagnosis with diplopia was a significantly associated factor for surgical treatment (2.2% in nonsurgery group vs. 6.6% in surgery group, $P = 0.007$). Male gender (adjusted hazard ratios [aHR] = 2.1, 95% confidence interval [CI]: 1.79–2.49) and low monthly income (aHR = 1.76, 95% CI: 1.16–2.67) were the risk factors for orbital floor fracture.

**CONCLUSION:** The incidence of orbital floor fractures increased in the Taiwanese population between 2001 and 2011. Men and low income patients were at increased risk of orbital floor fracture. More research is necessary to clarify what factors are driving the escalating incidence of orbital fractures in this national population.

**Keywords:**

Epidemiology, incidence, National Health Insurance Research Database, orbital floor fracture, Taiwan

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## Introduction

Orbital floor fracture is a common facial injury with many complications including diplopia, infraorbital numbness, decreased ocular movement, enophthalmos, and reduced vision. Appropriate treatment is necessary to avoid more severe morbidities. Because the orbit is comprised of multiple facial bones, there are a variety of studies from different specialties, including plastic surgeons, oral and maxillofacial surgeons, otolaryngology-head and neck surgeons, and ophthalmologists.[1-10] Younger age, male gender, and lower socioeconomic status have been reported as the associated risk factors for orbital trauma.[2-4,9] Almost all reports on orbital fracture in the literature have been retrospective case studies: The largest cohort of orbital floor fracture patients studied included 120,469 inpatients within the United States,[9] whereas the largest series from Asia included 733 surgically treated blowout fractures at one South Korean hospital.[11] However, the actual incidence and prevalence of orbital floor fracture are scarcely reported. To our knowledge, this is the first study estimating the epidemiology of orbital



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floor fracture in a nationally representative sample. The objective of this retrospective study was to characterize the epidemiology, demographics, comorbidities, and complications associated with orbital floor fractures and their surgical treatments in Taiwan.

## Materials and Methods

We performed a population-based retrospective study using the Taiwan National Health Insurance Research Database (NHIRD) which was established by the National Health Research Institutes and contains medical information and patient data for approximately 99% of Taiwanese citizens who are covered by the NHI program.[12] Data in the NHIRD does not contain any identifying information about patients or medical care providers. Institutional review board approval, an agreement to approve, monitor, and review biomedical and behavioral research involving humans, is preapproved by the National Health Research Institutes for de-identified data. The study was conducted according to the Declaration of Helsinki and approved by the Institutional Review Board for Human Research of Taipei Veterans General Hospital (2019-11-002ACF) and the patient consent is waived by IRB.

In the present study, a million registered residents were randomly selected from the registry file of NHIRD. Claims data of these subjects between 2001 and 2011 were collected and analyzed. All patients were identified using the International Classification of Disease-9 (ICD-9) diagnosis codes for orbital floor fracture (closed: 802.6; open: 802.7). Subjects' age was categorized into <20 years old, 20–40 years old, 40–60 year old, 60–80- years old, and >80 years old. Registrant setting, which represents where subjects live or work, was classified into three categories: urban, suburban, and rural—based on population density, medical resources, age, and education of the areas. Subjects' registered insurance fees are based on their occupation and monthly incomes. Registered insurance fees by monthly income were categorized as high > NTD$40,000 (USD$1250), middle NTD$20,000–40,000 (USD$625–1250), and low < NTD$20,000 (USD$625); "fixed-premium" if the subject belonged to a union, farmers' or fishermen's association; and "dependent" if a subject's insurance fee was based on another's income, including parents or partners.

The cases were categorized as either surgically or nonsurgically managed based on procedure codes. These procedures included: Enucleation, evisceration of eyeball, repair of eyeball wound, remove of hyphema, any type of scleral repair, orbitotomy with exploration, orbitotomy with removal of intraorbital foreign body, reconstruction of orbital socket, repair of orbital floor, repair of lacerated eyelid, plastic operation on canaliculi, and primary and secondary repair of lacrimal apparatus. Posttraumatic ocular complications were assessed using the diagnostic codes. These ocular complications were identified only if the diagnosis was a new comorbidity within 30 days of the incident orbital floor fracture diagnosis. Surgically managed cases were further categorized into early versus late treatment as defined by the time interval from the initial diagnosis of orbital floor fracture to surgical procedure, with time interval ≤7 days = early and >7 days = late. The complications between early and late surgery groups were also compared.

### Statistical analysis

Statistical analysis was performed using the SAS statistical package version 9.4 (SAS institute, Cary, North Carolina, USA). Annual incidence was calculated as newly diagnosed cases divided by the total population of individuals who have never suffered from orbital floor fracture before. Multivariate analysis using Cox regression modeling was done to calculate the adjusted hazard ratios (aHR) to examine the risk factors of orbital floor fracture. Fisher exact Chi-square analysis was used to compare the demographics and associated secondary diagnoses between nonsurgery and surgery groups and early and late surgery groups. The two-sided significance level was set at $P < 0.05$.

## Results

### Epidemiology

Between 2001 and 2011, 663 newly diagnosed cases of orbital floor fractures were identified in the NHIRD out of a total population at risk of 9,836,431 person-years. The average incidence of orbital floor fracture was 6.78/100,000 persons-years (range: 4.09-9.50 new cases per 100,000 persons per year). The incidence rate by male gender ranged from 4.73 to 11.56 new cases per 100,000 persons per year, while the incidence rate by female gender ranged from 2.19 to 7.73 new cases per 100,000 persons per year [Supplementary Table 1]. There was a significant increasing trend in the incidence rate of orbital floor fractures in the overall population (rate of 0.52 cases/100,000 person-years, $P < 0.001$) and in both males ($P = 0.001$) and females ($P = 0.011$) between 2001 and 2011 [Figure 1].

### Risk factors for orbital floor fracture

Multivariate analysis revealed that male gender (aHR = 2.11, 95% confidence interval [CI]: 1.79–2.49), low monthly income registered insurance fee payers (aHR = 1.76, 95% CI: 1.16–2.67), fixed premium registered insurance fee payers (aHR = 1.79, 95% CI: 1.16–2.76), and dependent registered insurance fee payers (aHR = 1.63, 95% CI: 1.05–2.52) were the risk factors for the incidence of orbital floor fracture in our study population [Table 1]. After adjusting for gender,

**Table 1: Unadjusted and adjusted[a] hazard ratios for incidence of orbital floor fracture**

| Characteristics | HR | *P* | aHR | 95 CI |
|---|---|---|---|---|
| Gender | | | | |
| Female | 1 (reference) | | 1 (reference) | |
| Male | 2.06 | <0.001 | 2.11[e] | 1.79–2.49 |
| Age (year old) | | | | |
| <20 | 1 (reference) | | 1 (reference) | |
| 20–40 | 0.98 | 0.80 | 1.02 | 0.82–1.26 |
| 40–60 | 0.74 | 0.006 | 0.83 | 0.63–1.09 |
| 60–80 | 0.88 | 0.39 | 0.91 | 0.67–1.23 |
| >80 | 0.51 | 0.25 | 0.51 | 0.16–1.60 |
| Registrant setting[b] | | | | |
| Urban | 1 (reference) | | 1 (reference) | |
| Suburban | 1.08 | 0.34 | 1.04 | 0.88–1.24 |
| Rural | 1.12 | 0.42 | 1.03 | 0.77–1.38 |
| Registered insurance fee | | | | |
| High monthly income >NTD$40,000 (USD$1250) | 1 (reference) | | 1 (reference) | |
| Middle monthly income NTD$20,000–40,000 (USD$625–1250) | 1.02 | 0.94 | 1.10 | 0.67–1.80 |
| Low monthly income <NTD$20,000 (USD$625) | 1.50 | 0.052 | 1.76[e] | 1.16–2.67 |
| Fixed premium[c] | 1.67 | 0.015 | 1.79[e] | 1.16–2.76 |
| Dependent[d] | 1.53 | 0.038 | 1.63[e] | 1.05–2.52 |

[a]Multiple analysis was done using cox-regression model. HRs were adjusted for gender, age, registrant setting, and registered insurance fee, [b]Registrant setting represents where subjects live or work and was classified based on population density, medical resources, age and education of the areas, [c]Fixed premium insurance holders mainly include individuals who belong to a union, farmers' or fishermen's association, [d]Dependent insurance holders are individuals whose insurance fee is based on another's income, including parents or partners, due to unemployment, [e]*P*<0.05. CI=Confidence interval, HRs=Hazard ratios, aHR=Adjusted hazard ratio

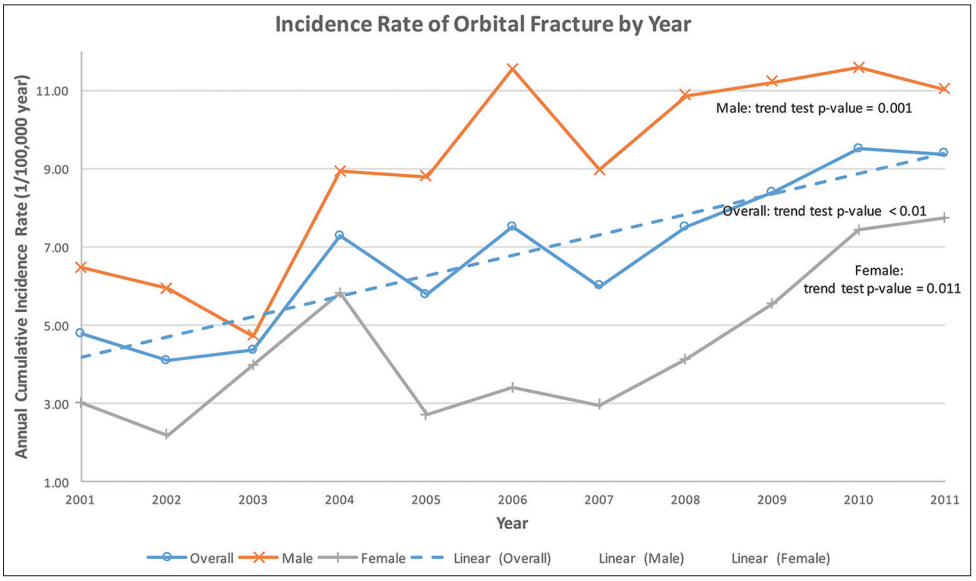


**Figure 1:** Incidence rate of orbital floor fracture by year

registrant setting, and registered insurance fee type, the incidence of orbital floor fracture was not significantly different between each age group.

## Comparison of nonsurgery versus surgery patient groups

The overall average age of patients was 37.6 –year old, 448 (68%) were male, 384 (58%) had insurance registered in an urban area compared to 216 (33%) and 63 (9%) in a suburban and rural setting, respectively [Table 2]. Based on registered insurance fee, most patients with orbital floor fractures had low monthly income ($n$ = 182, 28%) or dependency ($n$ = 250, 38%). Surgical treatments were performed in 213 (32%) patients with an average of 6.13 days passing from time of diagnosis to the time of procedure. Repair of orbital floor was performed in 69 (10.4%) patients. The demographics of nonsurgery and surgery patients with orbital floor fractures was comparable across gender and registrant setting. Patients who received surgical treatment were younger than those who did not (mean age 25.3 ± 13.6 years vs. 34.2 ± 18.6 years, $P$ < 0.001).

Registrant insurance fee was also significantly different between the surgical and nonsurgical group ($P = 0.008$).

The most common associated secondary diagnoses based off ICD-9 diagnostic codes were eyeball contusion ($n = 86$, 13%), diplopia ($n = 24$, 3.6%), and strabismus ($n = 21$, 3.2%) [Table 3]. Diplopia was significantly associated with surgical treatment (2.2% in nonsurgery group vs. 6.6% in surgery group, $P = 0.007$). Among 21 patients with strabismus, only 1 (4.8%) patient received muscle surgery for strabismus, whereas among 24 patients with diplopia, 3 (12.5%) patients developed strabismus but none of them received further surgical treatment for strabismus.

Of the 213 patients who underwent surgical management per procedural codes, 188 (88%) had early treatment. Patient demographics in the early and late treatment groups were comparable across age, gender, and registrant setting [Table 4]. A greater proportion of late surgically managed patients had diplopia than in the early surgically managed group (28% vs. 3.7%, $P < 0.001$).

## Discussion

This retrospective study examined the epidemiology, risk factors, demographics, and associated secondary diagnoses and procedures of orbital floor fracture cases in the Taiwanese population between 2001 and 2011. Over this period, we estimated the average incidence

**Table 2: Patient demographic characteristics**

| | Overall (*n*=663; 100), *n* (%) | Nonsurgery (*n*=450; 68), *n* (%) | Surgery (*n*=213; 32), *n* (%) | *P* |
|---|---|---|---|---|
| Age, mean±SD | 37.6±17.8 | 34.2±18.6 | 25.3±13.6 | <0.001 |
| Gender | | | | |
| Male | 448 (67.6) | 303 (67.3) | 145 (68.1) | 0.85 |
| Female | 215 (32.4) | 147 (32.7) | 68 (31.9) | |
| Registrant setting[a] | | | | |
| Urban | 384 (57.9) | 254 (56.4) | 130 (61.0) | 0.19 |
| Suburban | 216 (32.60) | 147 (32.7) | 69 (32.4) | |
| Rural | 63 (9.50) | 49 (10.9) | 14 (6.6) | |
| Registered insurance fee[a] | | | | |
| High monthly income >NTD$40,000 (USD$1250) | 26 (3.92) | 18 (4.0) | 8 (3.8) | 0.008 |
| Middle monthly income NTD$20,000 – 40,000 (USD$625–1250) | 41 (6.18) | 32 (7.1) | 9 (4.2) | |
| Low monthly income <NTD$20,000 (USD$625) | 182 (27.5) | 129 (28.7) | 53 (24.9) | |
| Fixed premium | 164 (24.7) | 122 (27.1) | 42 (19.7) | |
| Dependent | 250 (37.7) | 149 (33.1) | 101 (47.4) | |

[a]Registrant setting and insurance fee were categorized based on registry data in 2001. HRs were adjusted for gender, age, registrant setting, and registered insurance fee. Fixed premium insurance holders mainly include individuals who belong to a union, farmers' or fishermen's association while dependent insurance holders are individuals whose insurance fee is based on another's income, including parents or partners. SD=Standard deviation, HRs=Hazard ratios

**Table 3: Associated secondary diagnoses[a]**

| Associated diagnoses | Overall (*n*=663; 100), *n* (%) | Nonsurgery (*n*=450; 68), *n* (%) | Surgery (*n*=213; 32), *n* (%) | *P* |
|---|---|---|---|---|
| Contusion of eyeball | 86 (13.0) | 64 (14.2) | 22 (10.3) | 0.18 |
| Diplopia and/or strabismus | 42 (6.33) | 21 (4.7) | 21 (9.9) | 0.01 |
| Diplopia | 24 (3.62) | 10 (2.2) | 14 (6.6) | 0.007 |
| Strabismus | 21 (3.17) | 11 (2.4) | 10 (4.7) | 0.15 |
| Enophthalmos | 23 (3.47) | 13 (2.9) | 10 (4.7) | 0.26 |
| Eyelid laceration | 14 (2.1) | 10 (2.2) | 4 (1.9) | >0.99 |
| Retinal detachment | 9 (1.36) | 7 (1.6) | 2 (0.90) | 0.73 |
| Vitreous hemorrhage | 6 (0.90) | 4 (0.90) | 2 (0.90) | >0.99 |
| Laceration involving lacrimal system | 4 (0.60) | 1 (0.2) | 3 (1.4) | 0.10 |
| Hyphema | 4 (0.60) | 4 (0.90) | 0 | 0.31 |
| Globe rupture | 3 (0.45) | 3 (0.7) | 0 | 0.56 |
| Trochlear nerve injury | 2 (0.30) | 1 (0.2) | 1 (0.5) | >0.99 |
| Penetrating wound of orbit | 1 (0.15) | 1 (0.2) | 0 | >0.99 |
| Orbital hemorrhage | 1 (0.15) | 1 (0.2) | 0 | >0.99 |
| Oculomotor nerve injury | 1 (0.15) | 1 (0.2) | 0 | >0.99 |
| Abducens nerve injury | 1 (0.15) | 0 | 1 (0.5) | 0.32 |
| Endophthalmitis | 1 (0.15) | 1 (0.2) | 0 | >0.99 |

[a]Associated diagnoses were defined as newly diagnosed comorbidities made within 30 days of the initial orbital floor fracture

**Table 4: Demographics and associated secondary diagnoses in early and late treatment groups[a]**

| | Overall (*n*=213; 100), *n* (%) | Early treatment (*n*=188; 88), *n* (%) | Late treatment (*n*=25; 12), *n* (%) | *P* |
|---|---|---|---|---|
| Age, mean±SD | 25.3±13.6 | 25.1±13.5 | 26.7±14.8 | 0.48 |
| Gender | | | | |
| Male | 145 (68) | 126 (67) | 19 (76) | 0.37 |
| Female | 68 (32) | 62 (33) | 6 (24) | |
| Registrant setting | | | | |
| Urban | 130 (61) | 113 (60) | 17 (68) | 0.64 |
| Suburban | 69 (32) | 63 (34) | 6 (24) | |
| Rural | 14 (7) | 12 (6) | 2 (8) | |
| Registered insurance fee | | | | |
| High monthly income >NTD$40,000 (USD$1250) | 8 (4) | 5 (3) | 3 (12) | 0.15 |
| Middle monthly income NTD$20,000–40,000 (USD$625–1250) | 9 (4) | 7 (4) | 2 (8) | |
| Low monthly income <NTD$20,000 (USD$625) | 53 (25) | 48 (26) | 5 (20) | |
| Fixed premium | 42 (20) | 37 (20) | 5 (20) | |
| Dependent | 101 (47) | 91 (48) | 10 (40) | |
| Associated secondary diagnoses | | | | |
| Eyelid laceration | 4 (2) | 3 (2) | 1 (4) | 0.40 |
| Eyelid laceration involving lacrimal system | 3 (1) | 3 (2) | 0 | >0.99 |
| Vitreous hemorrhage | 2 (0.9) | 2 (1) | 0 | >0.99 |
| Retinal detachment | 2 (0.9) | 2 (1) | 0 | >0.99 |
| Contusion of eyeball | 22 (10) | 17 (9) | 5 (20) | 0.15 |
| Trochlear nerve injury | 1 (0.5) | 1 (0.5) | 0 | >0.99 |
| Abducens nerve injury | 1 (0.5) | 0 | 1 (4) | 0.12 |
| Diplopia | 14 (7) | 7 (4) | 7 (28) | <0.001 |
| Strabismus | 10 (5) | 7 (4) | 3 (12) | 0.098 |

[a]Early and late surgical treatments were defined based on the time interval between initial orbital floor fracture diagnosis and surgical procedure by ICD-9 codes (Closed: 76.78, Open: 76.79 reduction of facial fracture). Early: Interval ≤7 days. Late: Interval >7 days. SD=Standard deviation, ICD-9=International Classification of Disease-9

of orbital floor fracture in Taiwan to be 6.78 cases per 100,000 persons per year, ranging from 4.09 to 9.50 new cases per 100,000 persons per year. The overall increasing trend is similar to what was reported in Ko *et al*.'s 7-year retrospective study.[9]

We found that gender and registered insurance fee type, a proxy for socioeconomic status, were risk factors for orbital floor fractures. More specifically, aHR in this population found male patients to be at least twice as likely as female patients to develop incident orbital floor fractures. These findings support what has been reported in the literature on orbital trauma. Many studies report that male patients have outnumbered female patients by at least a 2:1 ratio, sometimes comprising up to 89% of the study population.[2] Although we did not have access to information about the causes of orbital floor fractures in these patients, other studies have speculated that males engage in a greater number of activities – motor vehicle accidents, physical assault, or sports-related mechanisms – that result in orbital floor fractures.[2,4] Most men and women did not undergo surgery for the management of orbital floor fracture, similar to findings reported by Yano *et al*. and Ko *et al*.[7,9]

In addition to male gender being a risk factor for developing orbital floor fractures, low income as determined by a patient's registered insurance fee was also found to be a statistically significant risk factor. The registered insurance fee listed in the NHIRD can be used as a proxy for socioeconomic status, as the insured are classified into categories depending on their employment status and income level. aHR suggest that individuals who had a low monthly income, fixed premium, or were dependent based on their insurance fees had more than 1.5 times the risk of developing orbital floor fractures. Moreover, our findings corroborate Ko *et al*.'s findings that a higher proportion of orbital floor fractures occur in those of a lower income bracket: 27.5% of orbital floor fractures overall occurred in individuals with low monthly income as determined by their registered insurance fee versus 3.92% in those with a high monthly income.

Interestingly, no age range was identified as a significant risk factor for orbital floor fracture despite our data showing the greatest proportion of orbital floor fractures occurring in patients ranging from 20 to 40 years old. This finding contrasts what others have reported about younger patients being at greater risk of orbital fractures.[5,11] Those studies did not perform Cox regression modeling and concluded that younger patients are at increased risk of orbital trauma based off a high proportion of patients being younger. In fact,

20–40 years old comprise the largest proportion of the Taiwan NHIRD, and thus we would expect to see a greater proportion of that age group represented in the cases.

Of those patients with orbital floor fracture, there were some significant differences between those who were managed surgically and nonsurgically. Surgery patients were significantly younger than nonsurgery patients (mean age 25.3 ± 13.6 years vs. 34.2 ± 18.6 years, $P < 0.001$). This finding was also reported by Ko *et al*. In addition, the surgery and nonsurgery groups of patients likely differ in the severity of their injury. Since the cost of medical care in Taiwan is relatively affordable and all citizens are covered under the NHI, there is not a significant barrier to accessing surgical management, if necessary.[12] Thus, patients who did not undergo surgical management likely had less severe cases.

In addition, a significantly greater proportion of patients who were surgically managed (6.6%) had diplopia than in the nonsurgical group (2.2%). The incidence of diplopia after orbital fracture ranges from 2.59% to 86%.[6,9,13-15] The higher rate of diplopia in the surgical group is unsurprising for two reasons: First, many have reported that diplopia in the context of an orbital fracture is an indication for surgical intervention.[16-19] Second, some have speculated that surgical management may potentially result in the development of diplopia, due to neurogenic causes from the surgical manipulation of the oculomotor nerve.[20-22]

Finally, for the 213 patients who were surgically managed, we further categorized them into early and late treatment groups. The early treatment group consisted of 188 (88%) patients while the late treatment group had 25 (12%) patients. Repair of orbital floor was performed in only 69 (10.4%) patients. Of those patients who received surgical repair of orbital floor, the average interval between the diagnosis of trauma and surgery was 3.67 days. It is interesting that most of the patients in our cohort received surgery with 1 week. A possible reason is that these surgeries contained not only reduction of orbital floor but also primary repair of eyelids and eyeballs. Most of these surgeries were primary repair. Unfortunately, detail operation procedures or secondary additional surgery cannot easily identify in this study since medical records cannot be obtained. Another reason is that the ICD-9 diagnostic code for orbital floor fracture might not put as main diagnoses if the patient suffered from major trauma that affect multiple sites. Patients usually seek for treatments from ophthalmologists after other injuries were recovered or treated. Besides, a significantly greater proportion of the late treatment group (28%) had diplopia than the early treatment group (3.7%). One explanation for this difference is the timing of surgery for diplopia associated with an orbital fracture: Though it is often an indication for surgery, diplopia itself is not an *urgent* indication for surgery, as periorbital edema can cause diplopia in the acute posttrauma setting. Thus, some providers even suggest delaying surgery so edema can subside and to operate only if there is persistent diplopia.[20,23]

This nationwide longitudinal retrospective study revealed interesting and significant trends in this population. Because of the high coverage rate of Taiwan's NHI, results derived from the NHIRD are more representative of the national population than previous studies which focused on single institutions. However, our study has some limitations. First, we could only identify patients using ICD-9 diagnostic codes and did not have access to their medical charts. Thus, we may have inadvertently overestimated the incidence by including patients who were only orbital floor fracture suspect patients. On the other hand, we may have missed some patients with orbital floor fracture secondary to major head trauma if they died before receiving an orbital floor fracture diagnosis. Next, we were unable to identify the causes of orbital floor fracture in this population. There are still some interesting issues could be studied, for example, the type of injury, the association of orbital floor injury and other concurrently traumatic comorbidities, and outcomes between different specialties of surgeons. Further clinical research is necessary to understand why the incidence of orbital floor fractures in the Taiwanese population has been increasing and whether these factors play a similar role in other populations.

In summary, our study revealed an increasing trend in the incidence of orbital floor fractures in Taiwan between 2001 and 2011. We also found that male patients and patients who are economically challenged were at increased risk of suffering from orbital floor fractures. Regarding those patients with orbital fractures, the majority did not undergo surgical treatment. Younger age and diplopia were associated with the surgical management. This information derived from a nationally-representative population in Taiwan may form the basis for future guidelines on orbital floor fracture management.

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## Conflicts of interest

Dr. De-Kuang Hwang, an editorial board member at *Taiwan Journal of Ophthalmology*, had no role in the peer review process of or decision to publish this article. The other authors declared no conflicts of interest in writing this paper.

## References


1. Ellis E 3rd, el-Attar A, Moos KF. An analysis of 2,067 cases of zygomatico-orbital fracture. J Oral Maxillofac Surg 1985;43:417-28.
2. Eski M, Sahin I, Deveci M, Turegun M, Isik S, Sengezer M. A retrospective analysis of 101 zygomatico-orbital fractures. J Craniofac Surg 2006;17:1059-64.
3. Gosau M, Schöneich M, Draenert FG, Ettl T, Driemel O, Reichert TE. Retrospective analysis of orbital floor fractures – Complications, outcome, and review of literature. Clin Oral Investig 2011;15:305-13.
4. Hwang K, You SH, Sohn IA. Analysis of orbital bone fractures: A 12-year study of 391 patients. J Craniofac Surg 2009;20:1218-23.
5. Shere JL, Boole JR, Holtel MR, Amoroso PJ. An analysis of 3599 midfacial and 1141 orbital blowout fractures among 4426 United States Army Soldiers, 1980-2000. Otolaryngol Head Neck Surg 2004;130:164-70.
6. Tong L, Bauer RJ, Buchman SR. A current 10-year retrospective survey of 199 surgically treated orbital floor fractures in a nonurban tertiary care Center. Plast Reconstr Surg 2001;108:612-21.
7. Yano H, Nakano M, Anraku K, Suzuki Y, Ishida H, Murakami R, *et al*. A consecutive case review of orbital blowout fractures and recommendations for comprehensive management. Plast Reconstr Surg 2009;124:602-11.
8. Shew M, Carlisle MP, Lu GN, Humphrey C, Kriet JD. Surgical treatment of orbital blowout fractures: Complications and postoperative care patterns. Craniomaxillofac Trauma Reconstr 2016;9:299-304.
9. Ko MJ, Morris CK, Kim JW, Lad SP, Arrigo RT, Lad EM. Orbital fractures: National inpatient trends and complications. Ophthalmic Plast Reconstr Surg 2013;29:298-303.
10. Wang N, Ma L, Wu S, Yang F, Tsai Y. Orbital blow-out fractures in children: Characterization and surgical outcome. Chang Gung Med J 2010;33:313-20.
11. Chi MJ, Ku M, Shin KH, Baek S. An analysis of 733 surgically treated blowout fractures. Ophthalmologica 2010;224:167-75.
12. Cheng T. Taiwan's national health insurance system: High value for the dollar. In: Okma KG, Crivelli L, editors. Six Countries, Six Reform Models: The Healthcare Reform Experience of Israel, the Netherlands, New Zealand, Singapore, Switzerland and Taiwan. New Jersey: World Scientific; 2010. p. 71-204.
13. Folkestad L, Westin T. Long-term sequelae after surgery for orbital floor fractures. Otolaryngol Head Neck Surg 1999;120:914-21.
14. al-Qurainy IA, Stassen LF, Dutton GN, Moos KF, el-Attar A. Diplopia following midfacial fractures. Br J Oral Maxillofac Surg 1991;29:302-7.
15. Converse JM, Smith B, Obear MF, Wood-Smith D. Orbital blowout fractures: A ten-year survey. Plast Reconstr Surg 1967;39:20-36.
16. Mazock JB, Schow SR, Triplett RG. Evaluation of ocular changes secondary to blowout fractures. J Oral Maxillofac Surg 2004;62:1298-302.
17. Burnstine MA. Clinical recommendations for repair of isolated orbital floor fractures: An evidence-based analysis. Ophthalmology 2002;109:1207-10.
18. Hartstein ME, Roper-Hall G. Update on orbital floor fractures: Indications and timing for repair. Facial Plast Surg 2000;16:95-106.
19. Dutton JJ. Management of blow-out fractures of the orbital floor. Surv Ophthalmol 1991;35:279-80.
20. Ramphul A, Hoffman G. Does preoperative diplopia determine the incidence of postoperative diplopia after repair of orbital floor fracture? An institutional review. J Oral Maxillofac Surg 2017;75:565-75.
21. Biesman BS, Hornblass A, Lisman R, Kazlas M. Diplopia after surgical repair of orbital floor fractures. Ophthalmic Plast Reconstr Surg 1996;12:9-16.
22. Silbert DI, Matta NS, Singman EL. Diplopia secondary to orbital surgery. Am Orthopt J 2012;62:22-8.
23. Putterman AM. Management of orbital floor blowout fractures. Adv Ophthalmic Plast Reconstr Surg 1987;6:281-5.

# Supplementary Material

**Supplementary Table 1: Prevalence and Incidence of orbital floor fracture in Taiwan between 2001 and 2011**

| | 2001 | | | 2002 | | | 2003 | | | 2004 | | | 2005 | | | 2006 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *n'* | *N'* | *P* | *n'* | *N'* | *P* | *n'* | *N'* | *P* | *n'* | *N'* | *P* | *n'* | *N'* | *P* | *n'* | *N'* | *P* |
| Prevalence | 51 | 942,018 | 5.41 | 47 | 929,420 | 5.06 | 48 | 916,925 | 5.23 | 74 | 906,366 | 8.16 | 58 | 899,478 | 6.45 | 72 | 892,592 | 8.07 |
| **Incidence** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** |
| Overall stratified | 45 | 941,888 | 4.78 | 38 | 929,245 | 4.09 | 40 | 916,713 | 4.36 | 67 | 906,117 | 7.39 | 52 | 899,163 | 5.78 | 67 | 892,229 | 7.51 |
| Age (year old) | | | | | | | | | | | | | | | | | | |
| <20 | 12 | 258,358 | 4.64 | 12 | 241,491 | 4.97 | 3 | 225,391 | 1.33 | 10 | 209,630 | 4.77 | 10 | 195,263 | 5.12 | 15 | 182,560 | 8.22 |
| 20–40 | 20 | 331,289 | 6.04 | 14 | 325,111 | 4.31 | 22 | 318,427 | 6.91 | 33 | 313,615 | 10.52 | 26 | 310,731 | 8.37 | 26 | 306,574 | 8.48 |
| 40–60 | 9 | 233,025 | 3.86 | 10 | 240,575 | 4.16 | 8 | 247,972 | 3.23 | 19 | 255,494 | 7.05 | 11 | 264,367 | 4.16 | 19 | 272,377 | 6.98 |
| 60–80 | 4 | 104,451 | 3.83 | 2 | 106,081 | 1.89 | 6 | 107,861 | 5.56 | 5 | 109,071 | 4.58 | 5 | 109,138 | 4.58 | 6 | 109,497 | 5.48 |
| >80 | 0 | 14,765 | 0.00 | 0 | 15,987 | 0.00 | 1 | 17,062 | 5.86 | 0 | 18,307 | 0.00 | 0 | 19,664 | 0.00 | 1 | 21,221 | 4.71 |
| Gender | | | | | | | | | | | | | | | | | | |
| Male | 31 | 479,008 | 6.47 | 28 | 471,804 | 5.93 | 22 | 464,880 | 4.73 | 41 | 459,107 | 8.93 | 40 | 454,845 | 8.79 | 52 | 450,614 | 11.54 |
| Female | 14 | 462,884 | 3.02 | 10 | 457,445 | 2.19 | 18 | 451,839 | 3.98 | 26 | 447,016 | 5.82 | 12 | 444,325 | 2.70 | 15 | 441,622 | 3.40 |

| | 2007 | | | 2008 | | | 2009 | | | 2010 | | | 2011 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *n'* | *N'* | *P* | *n'* | *N'* | *P* | *n'* | *N'* | *P* | *n'* | *N'* | *P* | *n'* | *N'* | *P* |
| Prevalence | 60 | 885,747 | 6.77 | 70 | 878,746 | 7.97 | 85 | 871,201 | 9.76 | 88 | 863,508 | 10.19 | 89 | 854,551 | 10.41 |
| **Incidence** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** | ***n*** | ***N*** | ***I*** |
| Overall stratified | 53 | 885,327 | 5.99 | 66 | 878,277 | 7.51 | 73 | 870,674 | 8.38 | 82 | 862,913 | 9.50 | 80 | 853,885 | 9.37 |
| Age (year old) | | | | | | | | | | | | | | | |
| <20 | 10 | 169,556 | 5.90 | 8 | 155,469 | 5.15 | 6 | 142,346 | 4.22 | 10 | 128,428 | 7.79 | 6 | 114,937 | 5.22 |
| 20–40 | 24 | 303,795 | 7.90 | 27 | 301,610 | 8.95 | 31 | 298,126 | 10.40 | 44 | 295,405 | 14.89 | 37 | 291,866 | 12.68 |
| 40–60 | 15 | 277,763 | 5.40 | 17 | 282,817 | 6.01 | 27 | 286,836 | 9.41 | 18 | 289,945 | 6.21 | 19 | 290,205 | 6.55 |
| 60–80 | 3 | 111,411 | 2.69 | 13 | 113,890 | 11.41 | 7 | 117,661 | 5.95 | 9 | 121,849 | 7.39 | 14 | 128,207 | 10.92 |
| >80 | 1 | 22,802 | 4.39 | 1 | 24,491 | 4.08 | 2 | 25,705 | 7.78 | 1 | 27,286 | 3.66 | 4 | 28,670 | 13.95 |
| Gender | | | | | | | | | | | | | | | |
| Male | 40 | 446,270 | 8.96 | 48 | 441,880 | 10.86 | 49 | 437,131 | 11.21 | 50 | 432,438 | 11.56 | 47 | 426,921 | 11.01 |
| Female | 13 | 439,057 | 2.96 | 18 | 436,397 | 4.12 | 24 | 433,543 | 5.54 | 32 | 430,475 | 7.43 | 33 | 426,964 | 7.73 |

*n'*=Number of orbital floor fracture cases, *N'*=Total population in the database, *P*=Annual prevalence of orbital floor fracture (1/100,000 year), *n*=Number of newly diagnosed orbital floor fracture cases, *N*=Total population at risk, *I*=Annual cumulative incidence of orbital floor fracture (1/100,000 year)