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Craniofacial/Pediatric

Long-term Morbidity of Traumatic Brain Injury Following Facial Fracture

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Background: Traumatic brain injury (TBI) is underreported in craniofacial trauma patients, and the long-term morbidity of TBI associated with craniofacial trauma is poorly defined. Current literature is limited in scope to TBI identification in the immediate posttrauma time frame.

Methods: A retrospective, cohort analysis of adult facial fracture patients presenting from February 2022 to February 2023 was performed. Data were collected for demographics, mechanism of injury, fracture pattern, Glasgow Coma Score, admission status, operative intervention, and concomitant injuries. Rivermead Post Concussion Symptoms Questionnaire surveys were given for evaluation of TBI symptoms at most recent follow-up. Statistical significance was accepted when the *P* value was less than 0.05.

Results: Of 232 facial fracture patients, 82 (35%) completed the Rivermead Post Concussion Symptoms Questionnaire. The mean age was 49.8 years, and mean follow-up time was 11.6 months (range, 2–22 mo). The rate of all patients with TBI symptoms at follow-up was 32.9%. Mechanism of injury, presence of multiple fractures, Glasgow Coma Score less than 15, concomitant injuries, and admission status were not significant predictors of TBI. Fractures requiring operative intervention had higher rates of TBI compared with nonoperative fractures (47.1% versus 22.9%, $P = 0.02$). Operative intervention was the only significant predictor of TBI symptoms at the time of follow-up (odds ratio: 6.268; 95% confidence interval: 1.322–29.744; $P = 0.021$) by multivariable logistic regression.

Conclusions: Craniofacial trauma is associated with persistent TBI symptoms. Surgeons treating this trauma population should screen for TBI to facilitate disease identification and specialty referral. *(Plast Reconstr Surg Glob Open 2024; 12:e6314; doi: 10.1097/GOX.0000000000006314; Published online 20 November 2024.)*

INTRODUCTION

Adult craniofacial (CF) trauma often results in traumatic brain injury (TBI), and it is estimated that 8.1%–67% of this adult CF trauma population have an associated TBI.[1–3] Mechanisms of injury commonly associated with TBI are also the most likely causes of facial fractures.[3–5] Despite these known associations, underreporting of TBI following CF trauma is commonplace, and up to 46% of these TBIs are undiagnosed at the time of injury.[1,2,6]

TBI is difficult to diagnose in trauma settings due to poor diagnostic measures and the perceived priority of other diagnoses.[7,8] Mild TBI, specifically, presents its own diagnostic difficulty given its indolent course and at times subtle presentation. Ninety percent of missed TBIs following facial fractures are mild TBIs, and the rate of undiagnosed TBI is significantly higher when patients with facial fractures are evaluated by nonneurosurgeon team members.[6] Timely TBI diagnosis is critical to long-term patient outcomes through patient education and referral to therapeutic resources.[9]

TBI can have long-term functional and neuropsychological consequences. Patients with TBI can report concerns with concentration, memory, coordination, vision,

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mental health, and autonomic regulation.[10] In addition, recent data show that TBI symptom severity is persistent up to 5 years postinjury.[11] There is a paucity of data on long-term TBI incidence in patients with facial fractures. Currently, the CF trauma literature is limited to reports of TBI incidence with facial fractures in the acute, postinjury time frame. Thus, the aim of this investigation is to assess the incidence and long-term symptoms of TBI in the CF trauma patient population.

PATIENTS AND METHODS

An institutional review board-approved, retrospective cohort study was conducted to identify all facial fracture patients evaluated at a single institution over a 1-year period (February 2022 to February 2023.) Inclusion criteria were presence of facial fracture confirmed by means of radiographic report if available or independent review of the computed tomography images, age older than 18 years, and presentation for follow-up care. Exclusion criteria included incomplete or absent patient data, lack of available radiographic reports or computed tomography images for independent review, and inability to consent to participation.

Patient records were reviewed for the following information: age, sex, mechanism of injury, fracture pattern, Glasgow Coma Score (GCS) at presentation, requirement of admission, need for operative fixation of fractures, and concomitant injuries. Patients were grouped based on their primary fracture pattern: nasal, orbital floor, zygomaticomaxillary complex (ZMC), and multiple fractures. The multiple fracture group included patients with ZMC or Le Fort type fractures with other associated fracture types (nasal, mandible, naso-orbitoethmoid, superior orbit, and frontal sinus). Individual assessment of each fracture pattern permutation was deemed inappropriate due to low sample sizes. Patients with nasal bone, orbital floor, or ZMC fractures who had an associated minor fracture, such as maxillary sinus or nasal septum fractures, were classified by their primary fracture pattern only. Isolated fractures were those with only one fracture present.

Next, the Rivermead Post Concussion Questionnaire (RPQ) was administered via telephone following verbal consent to patients who met the inclusion criteria. The RPQ is a 16-symptom, validated questionnaire for TBI-related symptom screening.[12,13] This screening tool assesses the burden of symptoms amongst four TBI phenotypes: physical, emotional, visual, and cognitive. Symptoms were rated as (0) not experienced at all, (1) no more of a problem, (2) a mild problem, (3) a moderate problem, and (4), a severe problem. A symptom severity score range of 0–64 was possible. Based on previous validation of the RPQ for TBI classification, a symptom score cutoff of more than 15 was used to determine if mild-to-severe TBI symptoms were present. Participant follow-up time was computed as the difference from date of initial fracture to date of survey completion in months.

Statistical analysis was completed using IBM statistics software SPSS (version 28). Frequency and proportion data were assessed for categorical variables, and mean data were reported for continuous variables. Tests of significance between groups were two-tailed *t* test and χ^2 test. Statistical significance was accepted with a *P* value less than 0.05. Multivariable logistic regression was used for prediction of TBI classification based on RPQ score. The enter method for variable selection was utilized. The Hosmer–Lemeshow test of goodness-of-fit test and area under the receiver operating characteristic curve were used to investigate the fitting behavior of the model.

Takeaways

Question: Are facial fractures associated with long-term traumatic brain injury (TBI) symptoms?

Findings: Based on a retrospective analysis of patients with facial fractures who have undergone TBI screening, 32% of patients with facial fractures experience long-term TBI symptoms. TBI symptom rates vary based on time from injury and specific fracture pattern. Need for operative intervention is the only patient-specific factor associated with long-term TBI symptoms in this cohort.

Meaning: Facial fractures pose a significant risk for long-term TBI symptoms, thus, highlighting the need for TBI screening in this population.

RESULTS

A total of 239 consecutive patients with facial fractures who met the above inclusion criteria from February 2022 to February 2023 were identified. Of these, 82 (34.3%) participated in the RPQ survey. The average patient age was 49.8 years and 54.9% were men. (**See table, Supplemental Digital Content 1**, which displays the summary of demographics and clinical characteristics for patients with facial fractures, **http://links.lww.com/PRSGO/D644**.) The proportion of respondents based on follow-up length was 11.0% (9 of 82) for 0–6 months, 41.5% (34 of 82) for 7–12 months, and 47.6% (39 of 82) for more than 12 months.

When grouped by major fracture pattern, 18 (22.0%) of 82 patients had nasal bone fractures, 28 (34.1%) of 82 patients had orbital floor fractures, 19 (23.2%) of 82 patients had ZMC fractures, and 17 (20.7%) of 82 patients had multiple facial fractures (**Supplemental Digital Content 1**, **http://links.lww.com/PRSGO/D644**). Mechanism of injury for all patients with facial fracture was ground level fall (41.5%), motor vehicle collision (25.6%), assault (20.7%), and other blunt trauma (12.2%). Of the patients, 48.8% presented with an isolated fracture. Presentation with GCS less than 15 occurred in 12.2% of patients with facial fracture. A total of 37.8% of patients with facial fractures required admission secondary to their trauma, 41.5% underwent operative intervention for their facial fractures, and 31.7% had an associated injury to another body system (**Supplemental Digital Content 1**, **http://links.lww.com/PRSGO/D644**).

The proportion of patients with present TBI symptoms at the time of RPQ survey was 32.9%. The mean interval between date of injury and date of RPQ survey was 11.6 months (range: 2–22 mo). Patients with present TBI symptoms were significantly younger than patients without TBI symptoms (mean age 42.7 versus 53.4, $P = 0.028$).

(**See table, Supplemental Digital Content 2**, which displays the prevalence of TBI based on RPQ score stratified by patient characteristics, **http://links.lww.com/PRSGO/D645**.) A total of 47.1% of patients who required operative intervention for facial fractures had present TBI compared with 22.9% of nonoperative patients (P = 0.022). The remaining variables of fracture pattern, mechanism of injury, GCS at presentation, need for admission, and concomitant injuries did not show significant differences between patients with present TBI symptoms and other patients (**Supplemental Digital Content 2**, **http://links.lww.com/PRSGO/D645**). Of 82 patients, 20 (24.4%) presented with a concomitant basilar skull fracture. The average RPQ score for this cohort with basilar skull fracture was 17.6 compared with 10.7 for patients without basilar skull fractures (P = 0.034).

Results of a multivariable logistic regression for the presence of TBI symptoms is shown in Supplemental Digital Content 3. (**See table, Supplemental Digital Content 3,** which displays the binary logistic regression analysis of predictors for TBI in patients with facial fractures, **http://links.lww.com/PRSGO/D646**.) The only significant predictor of TBI symptom presence was the need for operative intervention (odds ratio: 6.628; 95% confidence interval [CI]: 1.322–29.744; P = 0.021) Time since injury more than 12 months was a negative predictor of TBI presence with odds ratio of 0.048 (95% CI: 0.005–0.456; P = 0.008). The appropriateness of this model was confirmed by the Hosmer-Lemeshow χ^2 statistic of 6.767 with P = 0.562, and the area under the receiver operating characteristic curve was 0.830 (P < 0.001; 95% CI: 0.740–0.921).

DISCUSSION

Facial fractures are common in the trauma patient population, and an insignificant portion of the CF trauma literature has been devoted to the long-term neurologic sequelae of these injuries. Previous reports by McCarty et al[14] and Xun et al[1] show that both adult and pediatric patients who sustain facial fractures have significant TBI incidence at the time of injury with rates as high as 46% and 27.3%, respectively. Despite these data, long-term TBI-specific follow-up is not commonly reported. A previous investigation did show that patients with a history of facial fractures had increased rates of functional limitation, emotional distress, and posttraumatic stress disorder 6 to 12 months following their injury.[15] The data reported here show that 32.9% of patients who sustain a facial fracture have significant TBI symptom burden with an average follow-up time of 11.6 months. This further underscores the long-term morbidity of TBI in the facial fracture population and represents an important addition to the CF trauma literature.

Previous reports have demonstrated that fracture severity does correlate with brain injury severity and frequency.[2,3] As expected, rates of TBI symptom burden in this study differed based on fracture pattern with higher rates of TBI symptom burden in more severe fracture patterns such as ZMC or multiple fractures. This is in concert with the findings by Haug et al[16] that patients with midface or multiple fractures have higher rates of intracranial injury. These data are also consistent with previous computational modeling efforts that showed blunt CF trauma to the zygoma to be most injurious to the brain.[17–19] Further support for these conclusions is the predictive effect of operative intervention for TBI symptom persistence in our cohort. Fracture patterns with significant displacement or comminution necessitating repair are likely due to increased traumatic force. Basilar skull fractures are also associated with high energy mechanisms, and our patient cohort with concomitant basilar skull fractures had significantly higher RPQ scores (17.6 versus 10.7) compared with controls.

TBI was previously considered to be a self-limited pathology in trauma patients with rapid resolution of symptoms within 3–6 months postinjury. However, significant contributions by Nelson et al[11,13] as part of the multicenter Transforming Research and Clinical Knowledge in TBI (TRACK-TBI) group show that TBI symptoms are persistent and functionally deleterious up to 5 years postinjury. These data reveal that nearly 1 of 3 patients who sustain a facial fracture have significant TBI symptoms when surveyed at an average follow-up time of 11.6 months. This is an important finding for purposes of patient counseling and follow-up after facial trauma. Specialty referral for TBI rehabilitation should be considered for those with persistent TBI symptoms.

As previously noted, nearly half of all patients who present with TBI-like symptoms do not receive a formal diagnosis of TBI at the time of injury.[6] Furthermore, appropriate educational material and referrals for TBI-related follow-up care are not provided in the majority of cases.[20,21] Despite these challenges, validated treatments do exist for the common symptom phenotypes of TBI.[22–26] This further underlines the necessity for early recognition of TBI by providers caring for facial fracture patients. Specifically, plastic surgeons are often the only touchpoint for CF trauma patients after their initial presentation and may play a pivotal role in identification of TBI in this population. Neurosurgical consultation is typically limited to patients with severe intracranial pathology, thus missing the large proportion of patients with mild-to-moderate TBI. Only 7 of our surveyed patients were evaluated by Neurosurgery teams, and none of these patients went on to outpatient neurosurgical follow-up. At our institution, we now routinely screen all patients with facial fractures at their initial postinjury visit using the RPQ and at all following visits. Patients who screen positive for active TBI symptoms, those who required operative intervention, those with multiple fractures, and those with zygoma involvement are then referred to our physical medicine and rehabilitation colleagues as part of a specialty TBI clinic. This provides this patient cohort with access to vital neurorehabilitation resources. Another commonly utilized TBI screening/outcomes tool is the Glasgow Outcome Scale-Extended.[13]

The main limitation of this investigation is the absence of a non-CF trauma control group for comparison of RPQ survey data. However, there is extensive literature validating the RPQ in the patient population with TBI with a cutoff score of more than 15 for TBI persistence.[12,27] This supports the use of a cutoff metric for our facial fracture population. Another limitation of this investigation is the 1-time survey method for assessment of TBI burden. Future work should include prospective patient enrollment with standardized RPQ survey administration at the time of presentation and at future follow-up timepoints. These methods in conjunction with increased patient enrollment may further elucidate other predictors of long-term TBI.

CONCLUSIONS

TBI is an established phenomenon in the facial fracture population. Significant evidence substantiates the prevalence of TBI in the immediate postinjury time frame, but long-term data were previously lacking. This report demonstrates the significant long-term burden of TBI in the facial fracture population. High energy fractures as well as a need for operative intervention are associated with long-term TBI, and future efforts should further define predictors of long-term TBI. Dedicated awareness and screening for TBI is crucial for plastic surgeons to maximize long-term patient outcomes.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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