assessing the presence or absence of a light reflex or determining sluggish responses.

The absence of standardized protocols results in significant variability in assessment data across different nursing staff. This variability is influenced by factors like pupil abnormalities, eyelid edema, patient non-cooperation, ambient lighting, the use of sedatives and analgesics, as well as the assessor's level of expertise.[19] Consequently, precise measurements are often unattainable, and subtle changes in pupillary function can go undetected, increasing the likelihood of errors. According to research, measurement errors in pupil assessments can reach up to 0.5 mm, limiting their capacity to serve as an early warning system for changes in intracranial pressure.[20]

Compared with the traditional pupillary penlight method, TOS offers several advantages, including ease of operation, no radiation exposure, cost-effectiveness, and the ability to provide precise monitoring data. TOS can measure pupil diameter with an accuracy of 0.01 mm, allowing the detection of subtle changes in pupillary function that can serve as an early warning for rising intracranial pressure. This capability enhances the timeliness of therapeutic interventions, reducing the risk of neurological complications. TOS is especially valuable in emergency and ICU settings, where patients often require sedation and analgesia, and precise monitoring is critical for managing sedation levels.[21] Ultrasound technology, unlike traditional methods, is not limited by tissue transparency, enabling the visualization of lesions even in cases of ocular refractive media opacity or retrobulbar pathology. For patients with periorbital hematoma who are unable to open their eyes, TOS remains the only viable method for pupillary function assessment.

CONCLUSION

The TOS method for assessing pupillary function offers a precise, noninvasive monitoring technique that is user-friendly, radiation-free, safe, and capable of delivering reproducible results in a bedside setting. This technique allows for direct measurement of pupil diameter, pupillary light reflex, and dynamic pupil contraction time, enhancing the accuracy of assessments and enabling early detection of clinical deterioration. Medical personnel can acquire proficiency in TOS operation with brief, targeted training. Given its advantages, it is expected that bedside TOS will gain widespread acceptance among intensive care staff, eventually becoming a routine, objective assessment tool with broader clinical adoption for patients who are critically ill. However, the study acknowledges certain limitations, particularly in patients with orbital depression, where obtaining accurate measurements using TOS can be challenging. Further research is required to examine alternative methods that could be applied in these cases to overcome such challenges.

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The Incidence and Aetiology of Maxillofacial Trauma and Concomitant Traumatic Brain Injury in a Johannesburg Tertiary Hospital

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Objective: To investigate the incidence and etiology of maxillofacial trauma (MFT) and its association with traumatic brain injury (TBI).

Background: Anecdotal evidence suggests that there is an association between MFT and TBI and that higher incidences of TBI are associated with frontal bone and mid-facial fractures. Despite the large volume of maxillofacial facial fractures treated in the authors' unit, no study has been undertaken to establish the relationship between TBI and maxillofacial fractures.

Methods: This was a retrospective single-center cross-sectional study that was conducted on patients who presented at Charlotte Maxeke Academic Hospital emergency department with MFT and concomitant TBI over a period of 1 year (January 2019–January 2020). The primary predictor was maxillofacial fractures, which were classified into upper, middle, and lower thirds. The primary outcome variable was TBI indicated by the Glasgow Coma Scale (GCS) and Marshall computed tomography (CT) classification (radiological finding in CT).

Variables such as age, etiology, fracture type, and neurological injury indicated by the recorded GCS and Marshall CT classification (I–IV) were collected. Maxillofacial fractures were classified based on the anatomical location. The level of significance was set at $P < 0.05$.

Results: A total of 112 patients (102 males, 10 females) presented with MFT and concomitant TBI. The age group 30 to 39, followed by 20 to 29 years, was most affected. Respectively assault (n = 67), gunshots (n = 16), and falls (n = 16) were the main causes of injury. Supra-orbital rim fractures (P = 0.00193), frontal sinus fractures (P < 0.001,), and panfacial fractures (P < 0.001) were significantly associated with TBI. Severe TBI (GCS: 3–8) was associated with higher Marshall CT grading.

Conclusions: Facial fractures affecting the upper third and panfacial fractures pose a significant risk for TBI. To identify TBIs, a multidisciplinary evaluation of facial fractures is recommended, especially in high-risk groups.

Key Words: Computed tomography, emergency department, Glasglow Coma Scale, maxillofacial fractures, maxillofacial trauma, traumatic brain injury

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Traumatic brain injury (TBI) is one of the principal causes of death and invalidity, especially in the younger age groups.[1] Traumatic brain injury, defined as the transfer of mechanical energy to the brain elicited by an external force, resulting in acute neuropathological alteration, manifests postinjury as loss of consciousness, amnesia, altered mental status, other acute neurological signs, or death.[2,3] Mechanisms of TBI include blunt trauma from rapid acceleration/deceleration and penetrating injuries that result from direct mechanical impact, Gunshot wounds, (GSW) and blast waves.[2–4] The severity of TBI is assessed both clinically and radiologically.[4] The Glasgow Coma Scale (GCS), developed by Teasdale and Jennett,[5] serves as a rapid clinical assessment tool that quantifies the best eye-verbal-motor response to assign a score reflecting the level of TBI. Radiographically, noncontrast computed tomography (CT) scanning in the acute setting is the gold standard for the initial assessment of TBI due to its immediate acquisition and high sensitivity for detecting various neurological injuries.[3,6] Two CT-based prognostic models, the Marshall and Rotterdam classification systems, are often used to grade the severity of TBI. Both schemes are scoring systems that utilize CT imaging to predict the prognosis of TBI by correlating the level of injury with CT imaging findings.[7,8] Maxillofacial trauma (MFT) accounts for a significant percentage of overall trauma cases presenting to the emergency department (ED).[9,10]

A retrospective study conducted at Shengjing Hospital in China, examining the epidemiological patterns of maxillofacial fractures (MFFs) over an 8-year period and involving 829 patients, concluded that brain injuries are the most common injuries associated with MFF.[11] The relationship between facial injuries and TBI, however, awaits further elucidation. Some studies suggest that the maxilla, compressible midfacial bones, and adjacent air-filled sinuses form a shock-absorbing barrier against high-impact energy, thereby protecting the brain from damage.[12,13]

The alternative hypothesis posits that MFF and TBI occur concomitantly, with MFF serving as a significant indicator of the presence of an associated TBI due to the close anatomical relationship between the facial skeleton and the neurocranium.[14,15] Despite the large volume of MFF treated in our unit, no study has been undertaken to investigate the relationship between TBI and MFF. Anecdotal evidence seems to suggest that there is an association between MFT and TBI and that a higher incidence of TBI is associated with frontal bone and mid-facial fractures than with any other type of facial fractures. It is against this background that this study was undertaken to evaluate the relationship between MFF and TBI.

METHODS

Study Design

To address the research question, the investigators designed and implemented a retrospective single-center cross-sectional study for patients with MFF who presented to the Charlotte Maxeke Johannesburg Academic Hospital ED, University of the Witwatersrand in Johannesburg, over a period of 1 year, from January 2019 to January 2020. The study was approved by the institution's Human Research Ethics Committee (clearance number M210158). The population size was calculated using the StatCalc application. A population size of 216 was obtained with a confidence limit of 5% and an expected frequency of 42%. Nine hundred eighty-six patients presented to the ED with facial fractures. One hundred ninety patients sustained concomitant facial fractures and TBI. Of these, 112 patients met the inclusion criteria, having sustained MFF with an associated neurological injury. Patients with incomplete records and those under the age of 18 years were excluded from the study. The primary predictor was MFF, which was classified into upper, middle, and lower thirds. The primary outcome variable was TBI, indicated by the GCS and Marshall CT classification (radiological finding in CT).

Data Collection

The principal investigator recorded the data onto a data collection sheet. Variables such as race, sex, age, intoxicated/sober status (using gas chromatography), etiology, type of MFF, and neurological injury indicated by the recorded GCS and Marshall CT classification were collected. The clinical assessment of the neurological injury was determined by the GCS recorded upon admission to the ED. Traumatic brain injury was classified as mild (ordinal level 1: GCS: 14–15), moderate (ordinal level 2: GCS: 9–13), or severe (ordinal level 3: GCS: 3–8). Computed tomography imaging was analyzed by the principal investigator in consultation with a neurosurgeon skilled in the radiographic interpretation of CT imaging for TBI. Each patient who sustained a TBI was classified according to the Marshall grading system, from class I-IV. Maxillofacial fractures were classified based on their anatomical location.

Data and Statistical Analysis

The data were captured and tabulated in Microsoft Excel worksheets (Microsoft Office 365; Microsoft Corporation). Statistical analysis was performed using SAS version 9.3 (SAS Institute Inc.). Descriptive statistics, including percentages and frequencies, were used to summarize all categorical variables. To assess differences in proportions among groups, the χ^2 test of independence was applied. In addition, an ordinal logistic regression model was constructed in SAS, with the Marshall CT classification as the independent variable and the GCS as the dependent variable. A P value ≤ 0.05 was considered statistically significant.

RESULTS

A total of 6088 trauma patients were seen at Charlotte Maxeke Johannesburg Academic Hospital during the study period, of whom 986 had facial fractures. Of these, 190 patients sustained concomitant facial fractures and TBI. Seventy-eight (78) patients however did not meet the inclusion criteria and were, therefore, excluded from the study (Fig. 1). Of the remaining 112 patients, MFF and associated neurological injuries predominantly affected males ($n = 102$, 91%). The baseline clinical and biographic data of the participants are shown in Supplemental Table 1 (Supplemental Digital Content, Table 1, http://links.lww.com/SCS/H298). The age group most frequently sustaining MFF with concomitant TBI was 30 to 39 years (40%), followed by 20 to 29 years (38%), as shown in Figure 2. This study evidences blunt trauma as the most common etiological factor, which accounted for 91 patients (81%), followed by penetrating trauma (GSW; $n = 16$, 14%). Only 35 of the 112 patients had their blood alcohol concentration tested (10 were sober and 25 were intoxicated). Seventy-four patients with facial fractures sustained a mild TBI (66%), whereas 30 patients (26.7%) suffered from moderate TBI, and 8 patients (7.14%) sustained severe TBI (Supplemental Digital Content, Table 3, http://links.lww.com/SCS/H300).

Type of Fracture and Association With Traumatic Brain Injury

Of the 112 patients with MFF and TBI, the most common fracture type found was mandibular fractures (26.7%), followed by frontal sinus fractures (22.3%), zygomatic-maxillary complex fractures (16.9%), and orbital wall fractures (9.8%). Frontal sinus fractures ($P < 0.001$), panfacial fractures ($P < 0.001$), nasal bone fractures ($P = 0.0323$), and mandibular fractures ($P = 0.00147$) displayed a significant association with TBI, as illustrated by Supplemental Table 2 (Supplemental Digital Content, Table 2, http://links.lww.com/SCS/H299). Facial fractures affecting the upper third of the face were more frequently associated with a higher Marshall class and thus a more severe TBI than facial fractures in the lower third. Mandibular fractures were commonly associated with mild forms of TBI.

Association Between Glasgow Coma Scale and Marshall Computed Tomography Classification

Marshall CT classification classes 1 and 2 were strongly correlated with mild TBI (GCS: 14–15), while moderate TBI (GCS: 9–13) was associated with classes 2 and 3, and severe TBI (GCS: 3–8) was associated with classes 3 and 4. A Gamma statistic of 1 reflects a perfect positive relationship. The Gamma statistic of GCS and Marshall CT classification was 0.9494. The calculated Gamma statistic of 0.9494 demonstrated a very strong positive relationship, indicating that the GCS can predict the severity of TBI.

DISCUSSION

The purpose of this study was to determine the association between TBI and MFT. The specific aims were to estimate the frequency of TBI with different levels of fractures and to identify the risk factors for TBI in patients with facial fractures. We

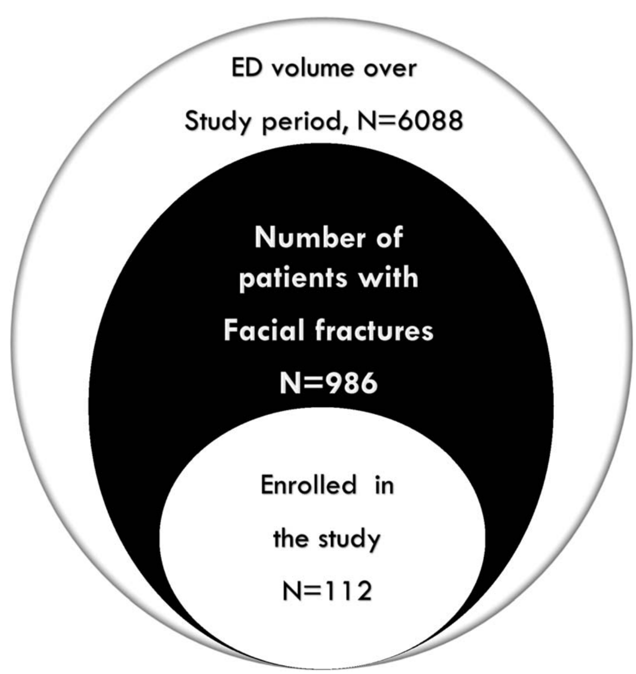

FIGURE 1. Enrollment volume of patients who presented to the ED at CMJAH. CMJAH indicates Charlotte Maxeke Johannesburg Academic Hospital; ED, emergency department.

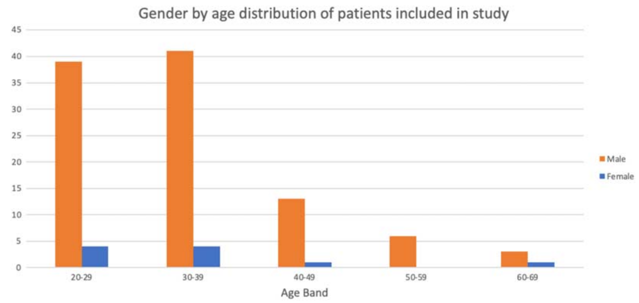

FIGURE 2. A bar graph illustrating the distribution of male and female patients who sustained facial fractures and TBI across different age groups. TBI indicates traumatic brain injury.

also aimed to determine the etiological, demographic, and radiographic characteristics of patients presenting to the ED with facial fractures and associated neurological injuries. We hypothesized that higher incidences of TBIs would be associated with frontal bone and midfacial fractures.

We found in this study that most of the patients were black males (in the second–third decade) who sustained their injuries from alleged assault followed by GSW. Furthermore, it was observed that although frontal bone, nasal bone, panfacial, and mandibular fractures were most frequently associated with TBIs, more severe forms of TBIs occurred with upper-third facial fractures. The global burden of disease study indicates that the leading causes of facial fractures worldwide are falls, interpersonal violence (IPV), and traffic accidents.[16] While the most prevalent mechanism of injury reported in urban countries is motor vehicle accidents, in South Africa, a developing country with a population of 60 million, IPV dominates as the chief etiological factor.[8,9,17]

In the present study, alleged assaults from IPV and GSW were the leading causes of MFF and TBI, surpassing falls and motor vehicle accidents. This trend is closely linked to the country's high crime rates. Falls predominantly occur in the elderly population, contributing to the higher rates of fractures in this demographic group.[18] The incidence of TBIs associated with MFFs worldwide is higher in males compared with females. In developed countries, the male-to-female ratio is reported as ranging from 2:1 to 4:1.[19] In contrast, the male-to-female ratio is reported to be much higher in developing countries, which our study aligns with (10:1). Male aggression and involvement in violent interpersonal conflicts, participation in extreme and contact sports, and employment in physically demanding jobs like construction contribute to the large gap in male predisposition to facial fractures and associated TBI.[14,18]

Males aged between 20 years and 39 years are principally affected, as confirmed in the present study. The incidence is significantly higher, presumably because this age group often engages in risky activities, sports, reckless driving, and various outdoor pursuits, which increase their susceptibility to these injuries.[14]

Brain injury carries a high risk of mortality and morbidity and may result in death, physical disability, or paralysis.[6,8,14] Although the population group studied is small, our findings seem to suggest that MFF is associated with TBI. We found that frontal sinus fractures are often diagnosed alongside brain injuries, likely due to the location of the trauma impact. In such cases, the frontal sinus does not appear to serve as a protective barrier for the brain. Furthermore, it was found that frontal bone, nasal bone, panfacial, and mandibular fractures were most frequently associated with TBI. Navaneetham et al[20] demonstrated a 1.5 times greater risk of TBI in patients with MFF, suggesting that patients with MFFs are at an increased risk for and usually suffer from TBIs simultaneously. This risk is linked to the close anatomic proximity of the facial bones to the cranium.[14,15] The presence of MFF might therefore serve as a significant predictor for TBI, challenging the hypothesis that facial bones played a role in shock absorption and deceleration by its compressive air-filled energy-absorbing structure.[12,21]

Contrary to our findings, Sieron et al[13] evaluated the physiology and function of the maxillary and paranasal sinuses and concluded that the paranasal sinuses serve as a crumple zone for cerebral structures during trauma, protecting the brain from injury. In addition, the vertical and horizontal facial buttresses have been described as areas of dense bone that neutralize forces directed toward the face, thereby protecting the brain from detrimental forces.[22] Although the mandible was the most frequently fractured bone in individuals with TBIs, upper facial third fractures were more likely to result in a severe form of TBI compared with those occurring in the middle or lower thirds of the facial skeleton. This could be due to the mandible's anatomical separation from the cranium, as it is suspended below the maxilla by muscles, ligaments, and soft tissues, which likely absorb the impact of external forces, making the mandible less likely to be associated with TBIs. In addition, mandibular condylar neck fractures serve as a neuroprotective mechanism, preventing dislocation into the cranium.[23]

The main limitation of the present study is its retrospective nature, which resulted in the exclusion of many patients with missing data. In addition, sobriety was ascertained by measuring blood alcohol concentration using gas chromatography. However, the National Health Laboratory services were not always able to perform this test, which made it difficult to assess the presumed risk association between alcohol intake and maxillofacial injuries. Our sample size was also affected by patients whose CT scans could not be retrieved from the system.

From the present study, we conclude that TBI should be suspected in patients presenting with frontal sinus, mandibular, nasal bone, and panfacial fractures, particularly in the young male population. For early diagnosis of concomitant TBI, a multidisciplinary evaluation of maxillofacial injuries is recommended, especially in high-risk groups. Early recognition of associated head trauma will significantly reduce the morbidity and mortality associated with these life-threatening injuries.[14,21] This study reveals an exceptionally high burden from maxillofacial injuries related to IPV and GSW and provides an important benchmark against which to compare future trends. Ultimately, as in many developing countries, there is a dire need to investigate and formulate strategies to address the social and economic determinants of violence. Future prospective studies, involving a larger number of patients, over a longer period that will include data on the role of alcohol and treatment outcomes of MFF are recommended to further strengthen and validate the findings in this study.

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Pediatric Craniofacial Injuries Involving Alcohol: An Epidemiologic Study

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Introduction: Alcohol intoxication significantly increases an individual's risk for a variety of injuries including craniofacial injuries, although this research is limited to adults. Further research is needed on pediatric craniofacial injuries related to alcohol use in children, a group inherently different in anatomy and developmental considerations from adults. This study aims to identify alcohol-related craniofacial injury patterns, injury mechanisms, and patient disposition in the pediatric population presenting to the emergency department.

Methods: A cross-sectional analysis of alcohol-related injuries in the pediatric population (0–18 years of age) was performed using the National Electronic Injury Surveillance System (NEISS) database from 2019 to 2023. Patient demographics, specific primary and secondary injury diagnoses, injury mechanism, location, and discharge disposition were collected. Descriptive statistics and χ^2 tests were used to understand injury patterns.

Results: A total of 266 patients with alcohol-related craniofacial injuries were identified, with an age range of 12 to 18 years. The most common craniofacial injuries were brain injury, facial laceration, and concussions. Additional injuries occurred in most patients and were often either poisoning or an additional craniofacial injury. Injury mechanisms included falls, motorized and non-motorized recreational vehicles, motor vehicle collisions, and others. Although most patients were discharged from the emergency department, some required transfer or admission, particularly those with brain injuries or fractures.

Conclusion: This study evaluates pediatric craniofacial injuries involving alcohol. Falls emerged as the most common injury mechanism, and most injuries occurred in older adolescents. This population had high rates of brain injury and concomitant injuries, highlighting the significant morbidity present.

Key Words: Alcohol-related injury, craniofacial injury, facial trauma, pediatrics

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