Characterization of Craniomaxillofacial Battle Injuries Sustained by United States Service Members in the Current Conflicts of Iraq and Afghanistan

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Purpose: To characterize and describe the craniomaxillofacial (CMF) battlefield injuries sustained by US Service Members in Operation Iraqi Freedom and Operation Enduring Freedom.

Patients and Methods: The Joint Theater Trauma Registry was queried from October 19, 2001, to December 11, 2007, for CMF battlefield injuries. The CMF injuries were identified using the "International Classification of Diseases, Ninth Revision, Clinical Modification" codes and the data compiled for battlefield injury service members. Nonbattlefield injuries, killed in action, and return to duty cases were excluded.

Results: CMF battlefield injuries were found in 2,014 of the 7,770 battlefield-injured US service members. In the 2,014 injured service members were 4,783 CMF injuries (2.4 injuries per soldier). The incidence of CMF battlefield injuries by branch of service was Army, 72%; Marines, 24%; Navy, 2%; and Air Force, 1%. The incidence of penetrating soft-tissue injuries and fractures was 58% and 27%, respectively. Of the fractures, 76% were open. The location of the facial fractures was the mandible in 36%, maxilla/zygoma in 19%, nasal in 14%, and orbit in 11%. The remaining 20% were not otherwise specified. The primary mechanism of injury involved explosive devices (84%).

Conclusions: Of the injured US service members, 26% had injuries to the CMF region in the Operation Iraqi Freedom/Operation Enduring Freedom conflicts during a 6-year period. Multiple penetrating soft-tissue injuries and fractures caused by explosive devices were frequently seen. Increased survivability because of body armor, advanced battlefield medicine, and the increased use of explosive devices is probably related to the elevated incidence of CMF battlefield injuries. The current use of "International Classification of Diseases, Ninth Revision, Clinical Modification" codes with the Joint Theater Trauma Registry failed to characterize the severity of facial wounds.

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Table 1. HEAD AND NECK WOUNDS AS PERCENTAGE OF ALL WOUNDS IN US SERVICE MEMBERS INVOLVED IN MAJOR US MILITARY CONFLICTS

Conflict	Percentage	Investigator
WWII	21	Beebe et al[1]
Korea	21	Reister[2]
Vietnam	16	Hardaway[3]
OIF/OEF	29	Owens et al[4]

Abbreviations: WWII, World War II; OIF, Operation Iraqi Freedom; OEF, Operation Enduring Freedom.

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Head and neck injuries have historically constituted 16% to 21% of battlefield injuries[1-3] (Table 1). In contrast, the ongoing US conflicts, Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), have had a 29% rate of craniomaxillofacial (CMF) battlefield injuries, with all other battlefield injuries remaining constant or declining.[4] Additionally concerning is the pattern of partial face traumatic avulsions seen by the Brooke Army Medical Center surgeons while the facility supported the entire level 5 evacuation mission in 2007. Therefore, the goal of the present study was to analyze the CMF wounding patterns throughout the entirety of the current US armed conflicts to understand this startling trend.

The present study analyzed the Joint Theater Trauma Registry (JTTR) for CMF battlefield injuries during OIF and OEF to describe the specific type, distribution, and various mechanisms of the injuries. The overall frequency of CMF battlefield injuries experienced in OIF/OEF was compared with those from previous wars and recent studies. The present database application was also evaluated for its capability in identifying the US service members with severe CMF battlefield injuries.

Patients and Methods

The JTTR is a registry of all US service members injured in OIF/OEF treated at any military facility and spanning all military services and all levels of care. The registry also includes civilian and non-US treated patients, listing battle injuries and nonbattlefield injuries. The registry was created to include entries starting from the beginning of OEF, October 2001, and has been continually updated. Patient information is extracted by trained data retrieval specialists from hard charts and on-line records. In accordance with the "International Classification of Diseases, Ninth Revision (ICD-9), Clinical Modification," superficial injuries were not coded when associated with more severe injuries at the same site.[5]

The JTTR was queried for all US service members who received treatment for CMF injuries (excluding burns, intracranial, intraocular, and ear injuries) using the ICD-9, Clinical Modification, codes 525.11, 802, 804, 830, 872, 873, 874, 900, 905 to 907, 910, 920, 925, and 959 sustained in OIF and OEF from October 19, 2001, through December 11, 2007, and the results were analyzed. Non-American and civilian patients were excluded. Care was taken to eliminate the multiple counting of injuries at different levels of care by removing repeated ICD-9 codes assigned to a given patient. Combatants classified as having nonbattlefield injuries, killed in action, or returned to duty (discharged from medical care within 72 hours after admission) were eliminated from the queried database before the final data analysis. Therefore, only US service members who were wounded in battle and not returned to duty were analyzed.

The queried database results were analyzed by performing the counts for each specific ICD-9 code, which were then compiled according to the type and mechanism of injury. The mechanism of injury (eg, explosion) was tabulated using the counts for each specific mechanism both per injury and per patient.

Results

During the 6-year period and at the time of the query, the data for 7,770 battle-injured soldiers were in the JTTR. Approximately 2,014 (26%) of these 7,770 battlefield-injured soldiers had CMF battlefield injuries. The 2,014 CMF battlefield-injured service members had 4,783 CMF battlefield injuries. For the CMF-injured service member, the average number of CMF battlefield injuries was 2.4 (range, 1 to 14).

Most CMF battlefield-injured service members were men (98% vs 2% women). The number of CMF battlefield injuries per soldier was nearly equivalent between the men and women, averaging 2.4 battlefield injuries for the men and 2.1 battlefield injuries for the women. The average age was 26 years (range 18 to 57). The incidence of CMF battlefield injuries by branch of service was Army, 72% (1,454 of 2,014); Marines, 24% (492 of 2,014); Navy, 2.0% (49 of 2,014); and Air Force, 1% (19 of 2,014).

Penetrating soft-tissue injuries and fractures accounted for most CMF battlefield injuries (58% and 27%, respectively; Table 2). Most facial fractures were open (76%; Fig 1). Of the 1,280 facial fractures, 365 involved the mandible (36%), 247 involved the maxilla/zygoma (19%), 181 the nasal area (14%), and 141 the orbital area (11%). The remaining 46 (20%) were listed as facial fractures, not otherwise specified. Other types of CMF battlefield injuries were listed as abrasions, dental injuries, contusions, dislocations, skull, and unknown.

Table 2. TYPES OF CRANIOMAXILLOFACIAL BATTLEFIELD INJURIES IN OPERATION IRAQI FREEDOM AND OPERATION ENDURING FREEDOM

CMF Injury	n	%
Soft tissue injuries		
Simple open or penetrating	2,128	44
Complicated open or penetrating	660	14
Total	2,788	58
Fractures	1,280	27
Abrasions	231	5
Dental injuries	204	4
Contusions	111	2
Dislocations	6	<1
Skull injuries	15	<1
Unknown	148	3

Abbreviation: CMF, craniomaxillofacial.

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Explosive devices were involved in most battlefield CMF injuries (84%; Table 3). Other methods included gunshot wounds (8%), motor vehicle accidents (2%), and not documented/other (2%). The following mechanisms accounted for 1% or less of the total: fragment/shrapnel, helicopter/plane crash, burn, blunt object, fall/jump from height, knife/sharp object, machinery/equipment, pedestrian, building collapse, and unexploded ordnance.

Discussion

The present study analyzed CMF battlefield injuries sustained by US service members in OIF/OEF during a 6-year period and represents one of the largest cohorts since the Vietnam War (1961 to 1975). CMF battlefield injuries occurred in 26% of the battle-injured US Service Members in OIF/OEF in the present analysis. A small number of studies have also evaluated CMF battlefield injuries in OIF/OEF[6-8] (Table 4). Wade et al[6] reported that 445 (39%) of 1,130 wounded had CMF battlefield injuries in OIF through analysis of the Navy-Marine Combat Trauma Registry during a 7-month period (March 1, 2004, to September 20, 2004).[6] That study included intracranial, intraocular, and ear injuries; however, these injuries were omitted from our analysis. The study period also included casualties after a major combat phase of OIF and correlated with an increased use of counterinsurgency warfare tactics. They concluded that these tactics, which frequently employed the use of improvised explosive devices, led to the large proportion of combat-related CMF battlefield injuries.

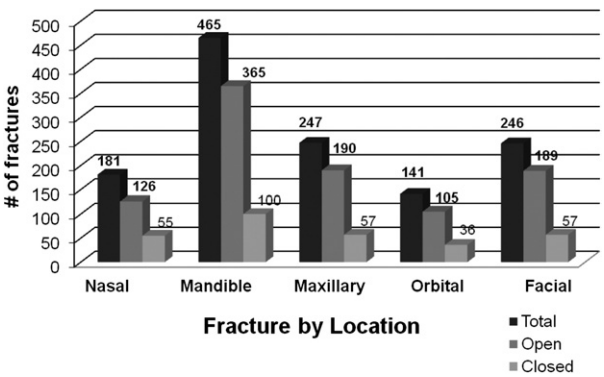

FIGURE 1. Distribution of combat-related craniomaxillofacial fractures in Operation Iraqi Freedom and Operation Enduring Freedom from October 2001 to December 2007.

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Table 3. DISTRIBUTION OF INJURY METHODS FOR COMBAT-RELATED CRANIOMAXILLOFACIAL INJURIES DURING OPERATION IRAQI FREEDOM AND OPERATION ENDURING FREEDOM

Method	Injuries (n)
Explosive	4,061 (84)
Gunshot wound	400 (8)
Motor vehicle accident	77 (2)
Other/not documented	81 (2)

The following mechanisms individually accounted for ≤1% of total: fragment/shrapnel, helicopter/plane crash, burn, blunt object, fall/jump from height, knife/sharp object, machinery/equipment, pedestrian, building collapse, and unexploded ordnance.

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In contrast, Montgomery et al[7] noted that 25% of 119 casualties from OIF had CMF battlefield injuries. Their study analyzed battle and nonbattlefield injuries from OIF, arriving at a single institution, Walter Reed Medical Center (Bethesda, MD) from March to June 2003.[7] They specifically analyzed the period correlating with the major combat phase of OIF, which involved more large-scale ground combat tactics.

Xydakis et al[8] analyzed the patients with CMF battlefield injuries from OIF/OEF arriving at Landstuhl Regional Medical Center at Rammstein Air Force Base in southwest Germany during a 14-month period (January 2003 to March 2004). They noted that 21% of the battlefield casualties (522 of 2,483) had CMF battlefield injuries. Their study was similar to ours, with the exclusion of intracranial and ophthalmic injuries; however, it included ear injuries. Alternatively, it is possible that some CMF battlefield injuries analyzed in our study incorporated these structures (ophthalmic and ear) in the "not otherwise specified" codes for facial injuries. These unspecified facial injuries in our data represented a small percentage (3%) of all CMF battlefield injuries.

Increased rates of CMF battlefield injuries seen in OIF/OEF can be attributed to the combined use of

Table 4. RECENT EPIDEMIOLOGIC STUDIES INVOLVING COMBAT-RELATED HEAD, FACE, AND NECK INJURIES OF US SERVICE MEMBERS IN OPERATION IRAQI FREEDOM AND OPERATION ENDURING FREEDOM

Conflict	Casualties With Head, Face, or Neck Injury (%)	Reference	Comment
OIF	39	Wade et al[6]	Retrospective, 7-month study of Navy-Marine CTR database analyzing 1,130 casualties after major combat phase in OIF and included nonbattlefield injuries
OIF	25	Montgomery et al[7]	Retrospective, 4-month, single-medical institution study analyzing injuries from major combat phase of OIF
OIF/OEF	21	Xydakis et al[8]	Retrospective, 14-month, single-medical institution study excluding intracranial and eye injuries

Abbreviations: CTR, Combat Trauma Registry; JTTR, Joint Theater Trauma Registry; other abbreviations as in Table 1.

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tactically placed surgical units, rapid evacuation of the wounded, and modern body armor.[4,9,10] Thus, soldiers who would have been killed in action in previous wars are surviving at increased rates, adding to the incidence of CMF battlefield injuries.

Chambers et al[11] described the development of a Surgical Shock Trauma Platoon and its experience during a 12-month period (March 2004 to 2005) in OIF. A Surgical Shock Trauma Platoon consists of 2 Forward Resuscitative Surgical Teams and a shock trauma platoon. A Forward Resuscitative Surgical System is an 8-person trauma surgical team located in close proximity to the combat operations. An experienced team can be set up within 1 hour and is capable of performing 18 major surgical operations for 48 hours without relief or resupply. Their study demonstrated a 97% survival rate among 579 significantly injured casualties.

Additionally, Mabry et al[12] evaluated the use of modern body armor by the US Army Rangers in Somalia (October 3, 1993) and noted that it reduced the mortality from injuries to the chest and prevented penetrating abdominal wounds from small fragments. Other causes of increased survival rates among battle-injured soldiers include potent antibiotics, improved anesthetic techniques, and improved postoperative care.[13] However, the face is exposed during battle operations and during travel through hostile territories. This, combined with the advances we have noted, has tended to increase the incidence of CMF battlefield injuries.

Explosive devices are involved in most CMF battlefield injuries in OIF/OEF during the 6 years studied. Currently, improvised explosive devices pose the greatest threat to coalition convoys and are the major cause of casualties. These wounds often lead to complicated open facial fractures that are grossly contaminated with metallic fragments, rocks, dirt, and other organic material.[14]

The present study found a large proportion (58%) of CMF battlefield injuries involved open or penetrating soft-tissue wounds. These wounds were classified as simple (44%) or complex (14%). Complex soft-tissue wounds are coded in the JTTR when the records mentioned delayed healing or treatment, foreign bodies, or infection. Recent reports regarding CMF battlefield injuries in OIF/OEF have lacked specific data regarding the facial fracture rates and their respective locations. The present study noted that facial fractures represent 27% of all CMF battlefield injuries. Many of these fractures were open (78%), and mandible fractures (36%) were the greatest among all types listed. The open-to-closed mandible fracture ratio was 3.65:1.

Regionally, the rate of combat fractures increased in a caudal direction along the maxillofacial complex. A similar pattern was noted in a study analyzing 1,135 patients with craniofacial injuries during the Iran–Iraq War (1984-1990), which found that injuries involving the lower one third of the face were the most common at 72.6%, followed by the middle third injuries at 36.3%, and the upper third injuries at 20.0%.[15]

The CMF area is commonly injured in OIF/OEF. The multiple, penetrating, soft-tissue injuries and fractures are the most common injuries. However, these injuries are the most difficult for surgeons to treat and, from clinical experience, have the worst outcomes. Increased survivability from the use of body armor, advanced battlefield medicine, and the increased use of explosives is probably related to an increased incidence of CMF battlefield injuries. A significant proportion of facial fractures (19%) were listed as not otherwise specified. Future retrospective studies should be performed to analyze these soldiers' charts to understand the difficulty in assigning specific ICD-9 codes that would offer more information.

The overall finding of our study has demonstrated that the use of the current ICD-9, Clinical Modification codes has failed to fully characterize the severity of facial wounds. Additional research should be initiated to develop a maxillofacial trauma coding module and improve current tracking methods. This module

should have the following specific goals: *1*) quantify the severity of maxillofacial injuries; *2*) assess the outcome of selected surgical treatment; *3*) increase communication between maxillofacial surgeons; *4*) estimate the disability; and *5*) be user friendly to facilitate widespread use and acceptance.[16] The information provided by a maxillofacial trauma coding module would prove especially useful for the wounded soldier, who is frequently treated by multiple institutions and surgeons within the US military health care system.

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