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Original Article

War-related maxillofacial injuries in Ukraine: a retrospective multicenter study

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Background: The invasion of Ukraine by Russian troops on February 24, 2022, had significant humanitarian consequences. This conflict provides valuable data on the types and characteristics of war-related injuries, their epidemiology under modern warfare conditions, and the effectiveness of medical support and treatment strategies applied under challenging military circumstances with limited staff and resources. Therefore, this study aimed to analyze the prevalence and characteristics of war-related maxillofacial injuries during the Russian–Ukrainian war.

Methods: This retrospective multicenter study examined the demographic features, etiology, and characteristics of ballistic injuries among military personnel and civilians. Data were collected from the maxillofacial departments of six specialized military and civilian medical institutions in Kyiv and its surrounding regions. The study analyzed 415 patients with gunshot and blast injuries admitted to these hospitals from February 24, 2022, to February 24, 2024. For each patient, parameters such as age, sex, social status, trauma-associated complications, concomitant injuries to other organs and systems, New Injury Severity Scores, and Facial Injury Severity Scale scores were recorded.

Results: Among the 415 patients, 96.9% were male. Isolated maxillofacial injuries were observed in 75 patients (18%), while ophthalmic injuries were present in 208 patients (50.1%). Primary care for the majority of patients was provided in military hospitals near the front line or in primary, secondary and tertiary regional medical institutions. Wound debridement and closure were performed as primary interventions in 358 patients (86.3%), and more than half of the patients received primary maxillofacial care within 24 hours of injury.

Conclusion: The primary cause of war-related maxillofacial injuries was high-energy blast trauma resulting from artillery strikes, mines, drones, rocket attacks, and bombings. War-related military trauma involved soft tissue damage in 97.1% of cases.

Keywords: Gunshot wounds / Health care surveys / Maxillofacial injuries / Military personnel / War exposure

INTRODUCTION

Current geopolitical tensions have increased the risk of high-intensity military conflicts and state-to-state wars [1]. Consequently, it is essential to modify the existing medical support system to address the challenges of modern warfare. Maxillofacial injuries represent a significant proportion of war-related injuries; however, their characteristics have evolved over the decades as new types of weapons and battlefield strategies have been introduced [2]. The overall incidence of head and neck trauma in modern combat has increased from 6% to 21% in early conflicts (e.g., World War II and the Korean War) to 21% to 43% in more recent conflicts (e.g., the Somali civil war, Operation Iraqi Freedom, and Operation Enduring Freedom) [3].

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The mortality rate for such injuries shortly after hospital arrival ranges from 2.8% to 11% [4]. Additional medicosocial consequences include severe facial disfigurement, functional loss, and the need for prolonged, multistage surgical rehabilitation.

The invasion of Ukraine by Russian troops on February 24, 2022, and the beginning of the full-scale war had significant humanitarian consequences, marking the largest armed conflict in Europe since World War II and generating tensions reminiscent of the Cold War [5]. Moreover, this conflict offers valuable data on the types and characteristics of war-related injuries, their epidemiology under modern warfare conditions, and the effectiveness of medical support and treatment strategies in scenarios where high standards of care must be maintained despite limited personnel and resources.

The military conflict led to hundreds of thousands of military casualties and tens of thousands of Ukrainian civilian casualties due to indiscriminate enemy attacks using missiles and drones (including cluster bombs) in densely populated areas, such as hospitals and energy grids [6]. As a consequence of these hostilities, 444 medical institutions were damaged or destroyed over the past 2 years [7]. According to the Office of the Attorney General, from the start of the Russian invasion until the end of 2023, 11,673 civilians died and 18,336 were injured. The number of injured soldiers—significantly higher—remains classified and is not available in open sources. In the second year of the conflict, while civilian casualties decreased, military casualties continued to rise [6,7].

The major causes of facial combat injuries include bullets and blasts (from both high-velocity and low-velocity missiles) [8,9]. In World War I, the destructive effects of high-power explosives and hand grenades resulted in significant facial mutilation. Since World War II, increased bullet velocities have led to more extensive damage to facial structures [10]. Primary blast injuries result from an explosion that causes a sudden increase in air pressure, predominantly affecting the air-containing sinuses and orbits. Secondary blast injuries are caused by shell fragments or debris near the explosion's center. Tertiary blast injuries occur when the victim is thrown by the blast, and quaternary blast injuries are associated with burns from the explosion's thermal effects [1].

Tissue damage caused by gunshot wounds generally occurs in three ways: direct impact or crushing, shock waves, and transient cavitation. The cavitation effect can extend to an area approximately 20 to 30 times the bullet's diameter. Limited intracranial elasticity further exacerbates tissue injury during cavitation [8]. Although these mechanisms are well documented in the literature, the development of new weapons and advancements in protective armor have significantly altered trauma patterns and their anatomical distribution.

Thus, the present study aimed to analyze the prevalence and characteristics of war-related maxillofacial injuries during the Russian–Ukrainian war through a retrospective analysis of data from six specialized military and civilian medical institutions in Kyiv and its surrounding regions.

METHODS

This retrospective multicenter study focused on the demographic features, etiology, and characteristics of ballistic injuries among military personnel and civilians wounded during the full-scale Russian–Ukrainian war. Data were collected from the maxillofacial departments of military and civilian hospitals in Kyiv and its surrounding regions. The departments involved in the study included the Center of Head and Neck Pathology at Kyiv Regional Hospital; the Department of Maxillofacial Surgery at Clinical Hospital No. 1; Kyiv Emergency Hospital; the Central Clinical Hospital of the State Border Service of Ukraine; Medical Center "Dobrobut"; and the Department of Maxillofacial Surgery at the National Military Medical Clinical Center "Main Military Clinical Hospital." These hospitals are part of a national, multifunctional, three-level medical support system. Initially, they provided primary care to wounded patients during the first months of intense hostilities in the Kyiv region. Later, they were integrated into the medical evacuation system to support military personnel and assist civilians injured during rocket attacks and bombings in Kyiv and its surrounding areas.

The study was based on an analysis of the medical documentation of 415 patients with gunshot and blast injuries admitted to the aforementioned hospitals between February 24, 2022, and February 24, 2024. Inclusion criteria included patients treated for gunshot or blast injuries, along with their complications or consequences resulting from hostilities or missile/drone attacks. Exclusion criteria included cases with insufficient clinical or radiological documentation, isolated superficial soft tissue injuries and dentoalveolar trauma not requiring hospitalization, traumatic injuries unrelated to hostilities, and patients who either refused treatment, were referred to facilities outside the county, or died before receiving specialized maxillofacial treatment.

The data were collected from various sources, including reports from field medical officers and medics, evacuation medical reports, and hospital medical records.

For each patient, the following parameters were examined: age, sex, social status (civilian or military), the pathophysiology of the injuries, injury patterns, and injury type/etiology (blunt trauma, bullet injury, or blast injury—including injuries caused by shell fragments, mines, bombs, missiles, and drones). Additional parameters included the time elapsed from injury to the first specialized medical intervention, any surgical interventions during previous evacuation stages, the presence of a tracheostomy, trauma-associated complications, concomitant injuries to other organs and systems, New Injury Severity Scores, and any concomitant somatic pathologies or harmful habits.

Maxillofacial injuries were analyzed based on the following signs: soft and bone tissue injuries of the head (including topographic anatomy, defect dimensions, and fracture types), the presence and nature of foreign bodies, dentoalveolar trauma, and dentition status. Concomitant head and neck injuries—such as traumatic brain injury, skull fractures, globe and facial nerve injuries, acubarotrauma, and burns—were also recorded. Functional deficiencies in masticatory and visual functions were assessed through thorough clinical examinations. The Facial Injury Severity Scale score was calculated for all patients. Facial Injury Severity Scale is widely used to classify the severity of facial injuries in adults and to provide numerical scores for different fracture and laceration patterns across all facial regions, making it one of the most reliable and specific scales for facial trauma [11,12]. Statistical analyses were performed using SPSS version 19.0 (IBM Corp.). Descriptive statistics are presented as frequencies, percentages, and means ± standard deviations.

RESULTS

Among the 415 patients meeting the inclusion criteria, males predominated (96.9%). The ratio of military personnel to civilians was 11.6:1. Most civilian victims were injured during early hostilities in the Kyiv region or during subsequent drone or rocket attacks. Patient ages ranged from 18 to 78 years, with a mean of 38.4 ± 10.2 years. Blast injuries—including those caused by shell fragments, mines, bombs, missiles, and drones—accounted for 87.2% of cases, significantly exceeding the prevalence of bullet injuries or blunt trauma.

Isolated maxillofacial injuries were present in 75 patients (18%). In all other cases, additional injuries to other organs and systems were observed (Table 1). Neurosurgical injuries and trauma to the extremities were the most frequently associated injuries. The median New Injury Severity Scores for the cohort was 7 (range, 5–12).

Acubarotrauma was observed in 156 patients (37.6%). Ophthalmic injuries occurred in 208 patients (50.1%). Diplopia, resulting from orbital floor fractures, was present in 12 patients (2.9%). Seventy patients (16.8%) had lost their eyes, and visual acuity decreased in 84 patients (20.2%). Other concomitant injuries are shown in Fig. 1.

Table 1. Etiology of trauma and demographic characteristics of the injured participants

Characteristics	Types	No. (%)
Sex	Male	402 (96.9)
	Female	13 (3.1)
Age (yr)	< 20	2 (0.5)
	20–29	83 (20.0)
	30–39	154 (37.1)
	40–49	119 (28.7)
	50–59	45 (10.8)
	≥ 60	12 (2.9)
Social status	Military	382 (92.0)
	Civilian	33 (8.0)
Type of injury	Blunt trauma	18 (4.3)
	Bullet injury	21 (5.1)
	Blast injury	362 (87.2)
	No data	14 (3.4)
Time from the moment of injury to the first specialized medical/maxillofacial intervention (hr)	< 24	230 (55.4)
	24–48	88 (21.2)
	> 48	97 (23.4)

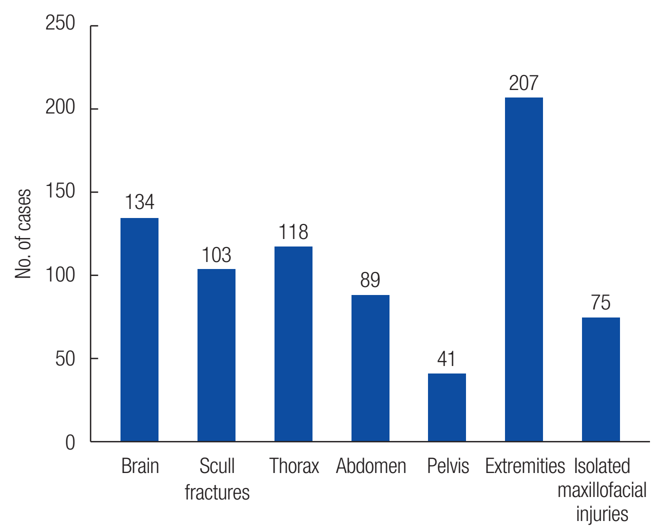

Fig. 1. Concomitant damage to organs and systems in patients with maxillofacial injuries.

Among the patients, 126 (30.4%) had somatic pathologies (e.g., endocrine, cardiovascular, or gastrointestinal diseases) that could influence the posttraumatic course. Additionally, 214 patients (51.6%) were smokers, and eight (1.9%) had drug and/or alcohol addiction.

Soft tissue injuries

Wounds or soft tissue defects of the face were present in 403 patients (97.1%). The locations of these wounds are shown in Fig. 2. On average, 2 ± 1.3 anatomical zones were affected per

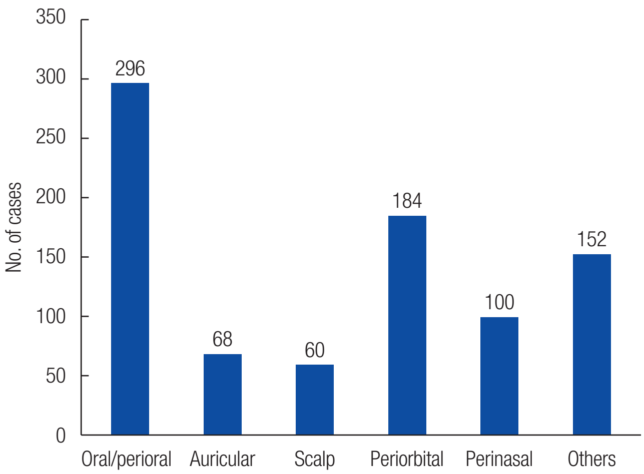

Fig. 2. Locations of soft tissue wounds of the head and neck.

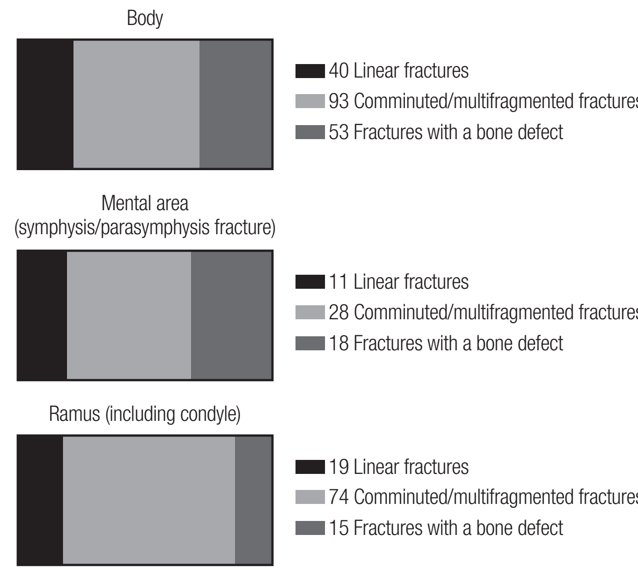

Fig. 3. Location of bone fractures depending on the anatomical region (number of cases).

patient. Skin burns were observed in 22 patients (5.3%). Foreign bodies, including bullets, shell or mine fragments, and glass or stone particles, were detected in 258 patients (62.2%). A single foreign body was observed in 45 patients (10.8%), whereas multiple foreign bodies were found in 213 patients (51.3%).

Metallic fragments were present in 234 patients (85.7% of all foreign body cases), while 14.3% had only nonmetallic foreign bodies (such as glass, stone/concrete, or wooden/plastic fragments). In all cases, metallic fragments were clearly detected via computed tomography scans and exhibited magnetic properties that facilitated their removal.

In 182 patients (45.2%), wounds and/or small defects were closed by direct suturing; local plastic techniques (e.g., local flaps and Z-plasty) were used in 166 patients (41.2%) to reconstruct small to moderate defects. Major defects requiring free microvascular flaps from distant donor sites for secondary-stage facial reconstruction (e.g., radial forearm flaps, anterolateral thigh flaps, or fibular flaps) were present in 55 patients (13.6%).

Bone injuries

Facial bone injuries were observed in 353 patients (85.1%). Mandibular fractures or defects were present in 233 patients (56.1%), while midfacial and frontofacial fractures were seen in 186 patients (44.8%). Complex panfacial fractures involving either the mandible or midfacial bones occurred in 75 patients (18.1%). Dentoalveolar injuries were diagnosed in 97 patients (23.4%). The median Facial Injury Severity Scale score was 4 (range, 2–5). Mandibular fracture locations were distributed as follows: the mental area (between the canine teeth) in 24% of cases; the body and angle in 72.5%; and the ramus (including the condyle) in 27.7%. Fractures confined to one anatomical zone were observed in 140 patients (60% of all fractures), while fractures involving two zones occurred in 76 patients (32.6%) and fractures involving three or more zones in 17 patients (7.4%). Multiple fragmented fractures and fractures with bone defects predominated over linear fractures at all anatomical locations (Fig. 3).

Posttraumatic mandibular defects were present in 129 (28.9%) patients. Continuous defects were observed in 93 patients (22.4%), while smaller defects with preserved mandibular continuity occurred in 27 patients (6.5%). Types of large continuous defects, classified according to the Brown system, are presented in Fig. 4.

The locations of midfacial bone injuries are presented in Fig. 5.

Primary care for the majority of patients in this cohort was provided in military hospitals near the front line or at primary, secondary, and tertiary regional medical institutions. Patients were subsequently evacuated to third-level medical institutions, including specialized maxillofacial departments in both civilian and military hospitals in Kyiv.

More than half of the studied patients received primary maxillofacial care within 24 hours. However, in 23.4% of cases, the time from injury to the first specialized medical intervention exceeded 48 hours. These delays occurred mostly in areas of intense hostilities, where evacuation challenges or captivity were factors.

Primary care included wound debridement and closure in 358 patients (86.3%). Tracheostomy for airway control was performed in 118 patients (28.4%). Osteosynthesis was conducted during primary wound revision in 109 patients (26.3%), and arch bars were applied in 64 patients (15.4%). Notably, 7.5% of patients received no intervention prior to admission. Often,

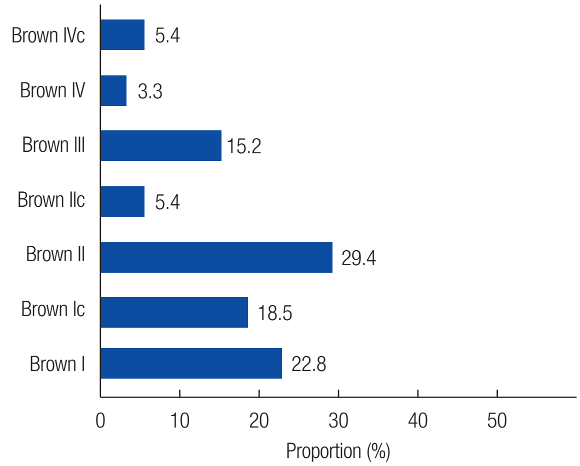

Fig. 4. Types of continuous mandibular defects in patients with military trauma.

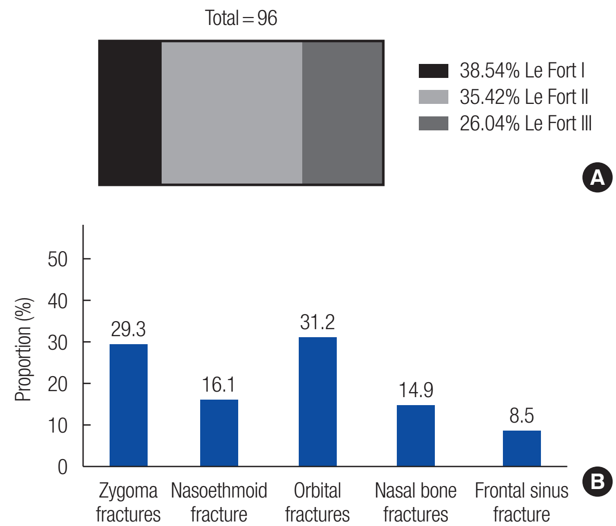

Fig. 5. Types of maxillofacial fractures in military trauma patients. (A) Types of maxillary fractures in patients with military trauma (%). (B) Types of midfacial fractures observed in patients with military trauma (%).

these interventions were performed under time constraints and limited resources by surgeons with varying degrees of experience in managing complex maxillofacial trauma and reconstruction. This situation resulted in multiple unsatisfactory outcomes from primary procedures and complicated secondary reconstructions in subsequent treatment stages. Additionally, 55 patients (13.3%) were admitted with signs of wound infection, predominantly caused by polyresistant bacterial strains (*Clostridium* or *Staphylococcus*). Primary care for maxillofacial injuries, performed before evacuation to medical centers in Kyiv, was often suboptimal.

DISCUSSION

Maxillofacial injuries are common in modern warfare. McIntyre [12] reported an average maxillofacial involvement of 16% among wounded soldiers in conflicts between 1914 and 1986—a value that exceeds expectations given that the head and neck region comprises only 12% of the total body surface area. Numerous authors have noted an increasing incidence of head and neck trauma in contemporary military conflicts. For example, during the United Kingdom's participation in the Iraq and Afghanistan conflicts, the proportion of maxillofacial injuries increased from 7% in 2005 to 18% in 2007 when neck injuries were excluded (although lacerations to the scalp and ear injuries were included) [13]. When neck trauma was incorporated (excluding brain, skull, and ophthalmic injuries), the proportion increased to 24% [14]. During the combined forces operation in East Ukraine from 2014 to 2019, the Ukrainian army suffered approximately 12,000 sanitary losses, with combat-related head injuries accounting for 31.9% and neck injuries for 1.9% [15]. These findings underscore the significant impact of modern weapons, protective armor, and tactical innovations on the patterns of maxillofacial trauma in contemporary military conflicts.

Russia's invasion of Ukraine sparked the largest armed conflict in Europe since World War II [16]. Major challenges facing the Ukrainian healthcare system in the ensuing years included disruptions in medical infrastructure and logistics, the exodus of highly trained medical professionals from frontline areas, shortages of expendable materials, significant population migration, and a dramatic increase in high-velocity blast and gunshot injuries among both combatants and civilians [17]. Massive casualties and unexpectedly high numbers of critically injured patients treated under conditions of limited staff and resources overwhelmed the healthcare system [18].

In response, a multifunctional, three-level medical support system was developed. Military and civilian hospitals were integrated into a unified national medical network designed to provide high-quality care to defense forces and civilians based on prevailing needs and conditions [1,5]. Under these circumstances, maxillofacial surgeons in both military and civilian hospitals have played a central role in treating war victims while continuing to provide regular services to patients with head and neck pathologies [19,20]. A nationwide survey of Ukrainian maxillofacial surgeons during 1 year of full-scale war found that 86.6% were involved in treating gunshot and ballistic injuries in both civilians and combatants [15].

This study collected data from both military and civilian maxillofacial departments in Kyiv—a city close to the frontline and integrated into the three-level evacuation system—thereby providing a representative cohort of war-related maxillofacial trauma cases. To our knowledge, this is the first study to analyze the epidemiology and structure of maxillofacial trauma in the Russian–Ukrainian war.

The data confirm that, similar to other military conflicts, this war affected both civilians and military personnel. The 33 civilians (8.0%) included in the study were either injured during hostilities in the Kyiv region or during subsequent rocket and drone attacks on Kyiv's infrastructure. In contrast, the majority of patients (92.0%) were military personnel evacuated from areas of intense combat.

As numerous publications have demonstrated, the trauma pattern is heavily influenced by the military characteristics of the conflict. This study revealed that most injuries (87.2%) were caused by blasts from shells, mines, bombs, missiles, and drones—weaponry used in large quantities in the ongoing war. Artillery, long regarded as the "king of battle," continues to dominate, accounting for approximately 80% of all casualties on both sides in the Russian–Ukrainian war [7].

During the Vietnam War, 71% of trauma admissions resulted from hostile actions. Among these, blast injuries (caused by shrapnel and antipersonnel mines) accounted for 74%, while bullet injuries accounted for 15% [12]. Although antipersonnel mines caused extensive injuries to the lower limbs, perineum, and trunk during the Vietnam War, they infrequently affected the head and neck; only 12% of injured U.S. combatants sustained head and neck injuries, of which 10% to 15% involved the maxillofacial region. In contrast, during the Syrian Civil War, 66.3% of trauma casualties were caused by gunshot wounds and 31.3% by blast injuries, with facial injuries being the second most common type after extremity injuries [2,12]. In the low-intensity conflict between the Israel Defense Forces and the Palestinian Armed Forces (September 2000–February 2001), most soldiers sustained head, neck, and face injuries (54.2%) or extremity injuries (50.0%). These high percentages likely reflect the extensive use of precision weapons (such as guns and stones, at 72.9%) rather than "area-effect" weapons like explosive charges or hand grenades. Notably, artillery was not used in this conflict [21].

The severity of a ballistic injury is directly related to the projectile's shape, size, and kinetic energy at impact, which in turn depends on the distance travelled [22,23]. High-velocity missiles cause extensive damage by releasing a large amount of kinetic energy at the point of impact. Since kinetic energy is proportional to the square of velocity ($E = ½mv^2$), the impact velocity is the most critical factor [1,24].

The predominance of high-velocity blast injuries in this cohort was associated with concomitant maxillofacial trauma to other organs and systems in 82% of patients. This finding underscores the critical role of multidisciplinary cooperation in the treatment and rehabilitation of war-related injuries. The most frequently associated injuries were to the extremities (49.9%) and the brain (32%), both of which significantly impacted prognosis and posttraumatic outcomes. Neurosurgical trauma, in particular, can lead to life-threatening complications and considerable delays in maxillofacial reconstruction. The issue of combined craniofacial trauma in military conflicts has been addressed in several studies. For example, Lew et al. [13] reported that craniomaxillofacial battlefield injuries occurred in 26% of injured U.S. service members in Operation Iraqi Freedom/Operation Iraqi Freedom, and these injuries are among the most challenging to treat, often resulting in the poorest outcomes. Ophthalmic trauma, frequently associated with midfacial fractures and defects, is another major concern; 50.1% of maxillofacial trauma patients in this study suffered eye injuries, with 9.2% experiencing eye loss. Consequently, the involvement of skilled ophthalmologists and oculoplastic surgeons in multidisciplinary trauma teams has become essential. In the Syrian War, approximately 63% of maxillofacial injuries were accompanied by extremity or other organ injuries, reflecting the widespread impact of shrapnel, missiles, or bullets [25].

The maxillofacial trauma pattern in this study was characterised by a high prevalence of combined soft tissue and bone injuries, the presence of foreign bodies of various origins in 62.2% of cases, a significant number of severe cases with large soft tissue and/or bone defects (67.5%), comminuted and panfacial fractures, and frequent wound infections with a high incidence of antibiotic-resistant organisms. In our series, 13.6% of patients required microvascular free-flap reconstruction. Mandibular fractures were slightly more common than midfacial fractures (56.1% vs. 44.8%). Additionally, 17.6% of cases involved combined injuries to both jaws, which is notably high.

During the Iraq–Iran War, 40% of maxillofacial injuries involved the mandibular region [21]. Studies of the Vietnam War reported that maxillofacial injuries were distributed as follows: mandible (21%), maxilla (19%), and other facial bones [26]. In a study by Levin et al. [2], maxillofacial injuries were primarily localized to the orbit (36%) and maxilla (44%).

The Ukrainian experience has highlighted challenges in providing primary care for war-related traumas and in the long-term management of individuals with severe maxillofacial injuries, both among civilians and soldiers [1]. Factors negatively impacting the quality of primary medical care in near-frontline hospitals include a shortage of qualified and experienced maxillofacial surgeons and limited resources such as plates, suturing materials, and specialized instruments. According to Wade et al. [27], only 40% of U.S. Navy personnel with head, face, and neck injuries require evacuation for treatment, whereas 89% of

British military personnel rely on the presence of oral and maxillofacial surgeons at major U.S. military hospitals in Iraq.

The introduction of potent antibiotics, improved survivability due to body armor, advances in anesthetic techniques, modern battlefield medicine, and better postoperative care have all contributed to increased casualty survival rates [10]. Mortality from maxillofacial injuries alone remains low, ranging from 0% to 3% [10]. Moreover, achieving adequate aesthetic and functional rehabilitation for war victims has become a matter of both medical and social importance.

Notably, during World Wars I and II, wound infections and sepsis were the most widespread and threatening complications of maxillofacial injuries. Today, this issue has regained significance due to the spread of antibiotic-resistant bacterial strains and wound contamination during prolonged evacuation periods. According to our data, 13.2% of patients were admitted with signs of active wound infection, and the risk of infectious complications in primary reconstructions of high-velocity blast trauma was significantly higher than that in conventional trauma cases.

The primary cause of war-related maxillofacial injuries in the Russian–Ukrainian war was high-energy blast trauma from artillery strikes, mines, drones, rocket attacks, and bombings. The male-to-female ratio among victims was 31:1, and the military personnel-to-civilian ratio was 12:1. War-related maxillofacial trauma included soft tissue damage in 97.1% of cases, the presence of foreign bodies (including multiple bodies) in 62.2% of cases, and the development of comminuted fractures and large facial bone defects in 67.5% of cases. These injuries necessitate long-term, multistage reconstruction, including microvascular techniques in 13.6% of cases. Maxillofacial trauma was accompanied by injuries to other organs and systems in 82% of patients. Among these, brain injuries (32%), extremity injuries (49.9%), and ocular injuries (24.3%) predominated, underscoring the importance of a multidisciplinary approach to the treatment of combat injuries. The treatment strategy and timing of primary specialized surgical care—often provided under conditions of limited time, resources, and personnel—significantly influence the final rehabilitation prognosis. Inadequate or incomplete primary surgical interventions can lead to complications (particularly infections) and complicate secondary reconstructions in subsequent treatment stages.

NOTES

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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Ethical approval

The Commission on Bioethical expertise and ethics of scientific research of Bogomolets National medical university was conducted than study was carried out taking into account existing bioethical norms and scientific standards for conducting medical/socio-statistical studies (expert opinion, protocol № 187, 23rd of September, 2024). Written informed consent was waived by the ethics agency.

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