Treatment Strategies in the Management of Maxillofacial Ballistic Injuries in Low-Intensity Conflict Scenarios

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Abstract

Introduction The facial disfigurement and functional debility resulting from craniomaxillofacial injuries in low-intensity conflict scenarios can physically and psychologically traumatize the afflicted personnel. Efficient and definitive management, with complete esthetic restoration and functional rehabilitation, is not only an organizational obligation, but also a tactical necessity to maintain a high state of morale among the troops. There exist two schools of thought on principles of management of such injuries. The older, three-phased approach consists of initial debridement and suturing, followed by conservative closed reduction in maxillofacial fractures using splints and ligatures, thereafter followed by delayed repair and late reconstruction of residual bone defects and deformities after the soft tissue healing is complete. The newer trend involves early and aggressive open surgical reduction and craniomaxillofacial fixation techniques along with reconstructive procedures carried out hand in hand with the soft tissue debridement and closure.

Aim The aim was to compare the efficacy of the two management protocols, namely the contemporary approach of early aggressive surgical intervention, versus the conservative approach of initial debridement, closed reduction

and delayed repair, as the definitive treatment modality of maxillofacial injuries sustained in low-intensity conflicts.

Methods This retrospective analytical study included 40 patients with maxillofacial injuries sustained in combat scenarios treated over a period of 3 years. These patients who had been treated for ballistic maxillofacial injuries were divided into two groups: The first group of 20 patients (Group 1) included those who had undergone an early, aggressive, surgical intervention, and the second group of 20 patients (Group 2) included those who had undergone resuscitation and primary soft tissue closure followed by conservative, closed reduction techniques, delayed repair (including open reduction and internal fixation (ORIF) procedures), and late reconstruction of bone soft tissue defects (which included utilization of various grafts and flaps). Both groups were evaluated and compared for postoperative recovery and early and late complications such as impaired esthetic results and impaired functional recovery.

Results Early, definitive, and aggressive maxillofacial surgical techniques proved superior to the conservative approach by bringing about primary bone healing and minimizing residual deformities and subsequent scar contractures, thus yielding improved functional as well as superior esthetic outcomes.

Conclusion In today's low-intensity conflict scenario, the emphasis in management of maxillofacial injury victims should be on an early, definitive, and aggressive surgical repair and reconstruction of the facial skeleton, thus restoring quality of life to these soldiers, sparing them life-long indignity after a potentially severe esthetically and functionally debilitating injury.

Keywords Low-intensity conflicts (LIC) · Gunshot wounds (GSWs) · Improvised explosive devices (IEDs) ·

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Ballistic trauma · Craniomaxillofacial injuries (CMFs) ·
Open reduction and internal fixation (ORIF)

Introduction

Studies on trends and patterns of injuries sustained in low-intensity military conflict scenarios have been shown to largely involve extremity injuries (73%), followed by head and neck injuries (22%), and thoracic and abdominal injuries (5%). Their most common mode is ballistic projectiles and GSWs (41.4%) followed by splinter and shrapnel injuries from improvised explosive devices (IED) blasts (39.2%) [1].

With the conventional wars becoming rarer, low-intensity conflicts (LICs) have become the norm of the day. LICs are “insurgencies, organized terrorism, paramilitary crime, sabotage and other forms of violence in the shadow area between peace and open warfare. It is a form of warfare in which the ‘enemy’ is more or less omnipresent and unlikely to ever surrender” [1].

Military trauma has kept pace with the development of deadlier and more powerful weapon systems. Ironically, an increased incidence and severity of craniomaxillofacial (CMF) injuries have been observed in present day LIC scenarios, attributable to several factors such as, improvement in contemporary body armor technology, but deficient head and maxillofacial protective gear, making the CMF region vulnerable on the battlefield; advances in battlefield medicine leading to improved casualty survival rates; changes in weaponry and armaments being used these days, which are designed more to injure than to kill; and an increased frequency of surprise close proximity ambushes with gunshot wounds (GSWs) at point blank range, as well as encounters with IEDs used by insurgent forces [2].

The predominant mechanisms of maxillofacial trauma in a LIC theater include penetrating as well as blunt trauma [2], common injuries being GSWs; splinter and shrapnel injuries; IED, grenade and mine blast injuries; and non-battle casualties (NBCs) resulting from road traffic accidents (RTAs) or falls from heights. Craniomaxillofacial (CMF) battle injuries include fractures, soft tissue injuries like lacerations and avulsions, soft and hard tissue loss, nerve and vessel injuries, closed and open head injuries with traumatic brain injuries (TBIs), and burns to the face and neck.

The patient’s primary stabilization involves Advanced Trauma Life Support (ATLS), including establishment of airway and control of hemorrhage. This is directly followed by an initial or preliminary survey to identify life- and limb-threatening injuries and addressing them. Thorough examination with the help of appropriate imaging followed

by detailed definitive treatment planning and reconstruction of soft and hard tissue defects follows thereafter. Complexity and diversity of maxillofacial ballistic injuries pose significant challenges to the treating surgeons as these injuries present with significant soft and hard tissue destruction, maceration, and defects [3].

There exist two schools of thought on principles of management of such injuries. The older, three-phased approach [4] consists of initial debridement and suturing, followed by conservative closed reduction of maxillofacial fractures using splints and ligatures, thereafter followed by delayed repair and late reconstruction of residual bone defects and deformities after the soft tissue healing is complete. The newer trend involves early and aggressive open surgical reduction and rigid/semi-rigid internal fixation techniques (ORIF) and reconstructive procedures carried out hand in hand with the soft tissue debridement and closure [5, 6].

Aim

To compare the efficacy of the two management protocols, namely early aggressive maxillofacial surgical intervention, versus the conservative approach of initial debridement, closed reduction, and delayed repair, as the definitive treatment modality of maxillofacial injuries sustained in low-intensity conflicts.

Methods

This retrospective analytical study included 40 patients with maxillofacial injuries (involving the mandible, maxilla, zygomatic complex, orbital, frontal, or nasoethmoid regions), sustained in combat scenarios treated over a period of 3 years. These patients who had been treated for maxillofacial injuries were divided into two groups: the first group of 20 patients (Group 1) included those who had undergone an early, aggressive, surgical intervention, by ORIF of fractured bones of the maxillofacial skeleton, employing mini and microplate fixation techniques with/without immediate bone grafting (Figs. 1, 2, 3, 4 and 6),

Fig. 1 a–h A patient (Group 1) exhibiting the entry point of an AK-47 bullet below the chin, traversing upwards, fracturing the mandible, perforating the tongue, fracturing the maxilla and thereafter exiting through the forehead. **i–l** Early aggressive open surgical reduction and internal fixation (ORIF) carried out as indicated by the white arrows, of the frontal bone, maxilla and mandible, hand in hand with tissue debridement, anterior nasal packing to control hemorrhage, and primary closure. **m–p** Immediate postoperative appearance and CT scan showing the well aligned and fixed fractured fragments of the maxillofacial skeleton with the implants in situ as indicated by the black arrows

Fig. 2 **a, b** Same patient as in Fig. 1, 6 months after surgery, showing good esthetic and functional results. Patient had a missing left central incisor and a residual palatal fistula and oro-nasal communication. **c–g** Early secondary reconstruction of the palatal

defect carried out using an anteriorly based dorsal pedicled tongue flap. **h, i** Successful closure of the palatal fistula and dental rehabilitation of the patient with a prosthesis

and the second group also included 20 patients (Group 2), who were managed using conservative, closed reduction techniques, followed by delayed repair and late reconstruction of bone defects (Figs. 5 and 7).

Considering the grave, life threatening, widely varied, unpredictable, and bizarre nature of these types of injuries, standardized comparison protocols have not been published/advocated till date. In order to reduce bias due to

multicentric management involving multiple teams and to ensure objectivity, this study was based on a simple protocol which included a comparison of parameters concerned with esthetic as well as functional outcomes in addition to early and late complications.

Both groups were evaluated for postoperative recovery and early and late complications such as wound site infection, delayed healing, non-/mal-union, residual

Fig. 3 a–d GSW to the face with the bullet entry wound in the right retromandibular region and exit wound through the left cheek after shattering the left body of mandible e Aggressive primary surgery with debridement as well as ORIF of the comminuted fracture of the

mandible, using titanium miniplate as well as reconstruction plate. f Tamponade of the entry wound using Foley's catheter, to control bleeding

deformities, scar contractures (Table 1). The two groups were also compared with respect to differences in cosmetic and esthetic results as well as functional recovery in terms of speech, deglutition, masticatory efficiency, occlusion, interincisal mouth opening, and neurological deficits (Table 1).

Statistical Analysis

SPSS 16.00 was used to statistically analyze the results.

Results

Early, definitive, and aggressive maxillofacial surgical techniques proved superior to the conservative approach by bringing about primary bone healing and minimizing

residual deformities and subsequent scar contractures, thus yielding improved functional as well as superior esthetic outcomes, as revealed in the statistical analysis.

Discussion

High-velocity GSWs to the head and neck region result in debilitating and mutilating facial injuries [7], characterized by severe bone fragmentation and soft tissue avulsion with splintered bone fragments acting as less energized secondary missiles [8, 9]. Such injuries are quite challenging to manage as they require both hard and soft tissue reconstruction for esthetic restoration as well as functional rehabilitation.

Management algorithm of maxillofacial battle injuries includes [4, 10]:

Fig. 4 a–d Entry wound at right submandibular region (Tamponade done using a Foley’s catheter to control hemorrhage), shattering the angle and body of the mandible, thereafter lacerating the tongue and exiting through the left cheek. e 3-D computed tomographic scan revealing the extent of fragmentation and destruction of the mandible.

f–h Harvesting of an iliac crest block graft for immediate reconstruction of the mandible after thorough wound debridement. Graft fixed in place using a Titanium reconstruction plate and mini-bone plates and screws. (Courtesy: Maj Anson Jose, Srinagar)

- (a) Emergency care and Patient Stabilization by ATLS protocols [4].
- (b) Preliminary survey, initial evaluation other emergent interventions, and treatment planning.
- (c) Initial surgical management involving wound debridement and skeletal stabilization using external skeletal fixators, arch bars and maxillomandibular fixation, mini-bone plates, and reconstruction plates.
- (d) Minimal soft tissue revision to ensure soft tissue coverage of exposed bone.
- (e) Definitive management guided by esthetic and functional demands: Reconstruction of soft tissue defects and exposed bone coverage using local soft tissue advancement flaps, such as forehead, Abbe flaps, pedicled deltopectoral, sternomastoid, pectoralis major myocutaneous flaps [11]. Reconstruction of bone continuity defects using free bone grafts such as autogenous anterior iliac crest block grafts [12].
- (f) Late revision surgery, e.g., soft tissue debulking, distraction osteogenesis,
- (g) Rehabilitation by means of dentures, dental implants, palatal obturator fabrication.

Based on the time frame in which the above steps are carried out, that is, whether they are performed in a continuum or in a staged manner, there are two main schools of thought in the management of these types of injuries:

Traditional, Conservative, Three-Stage Management with Late Definitive Surgical Repair and Delayed Reconstruction

This consists of initial debridement and suturing, followed by conservative closed reduction of maxillofacial fractures using splints and ligatures, thereafter followed by delayed repair and late reconstruction of residual bone defects and deformities after the soft tissue healing is complete.

Advantages

1. Benefits of delayed reconstruction include lesser necrotic debris and reduction in post-traumatic edema at the time of definitive surgery, hence a better evaluation of the tissue defects to be restored.
2. High-energy GSWs and blast injuries (in particular, wounds received from IED devices, with their associated contamination) to the face are likely to benefit from serial debridement and delayed closure after soft tissues have stabilized, especially in the military arena in which delays in medical care are more common.
3. Adequate time allowed for resolution of edema and decreased of inflammation provides for a better assessment of the pre-traumatic facial structure.
4. Reduced infection rate, hence a more assured take of the grafts [13].

Fig. 5 a–d A Group 2 patient who sustained severe maxillofacial injuries resulting from Gunshots to the face at point blank range by a AK-47 weapon. **e, f** Immediate resuscitation of the patient carried out together with arrest of hemorrhage, surgical debridement and soft

tissue repair and closure. Definitive management postponed for a year due to poor general and neurological status of the patient. (Courtesy: Maj Anson Jose, Srinagar)

Disadvantages and Limitations

1. Delayed reconstruction often results in debilitating wound contracture, resulting in significantly more structural and functional deformity, making future rehabilitation difficult [14].
2. Delayed bone reconstructions frequently suffer from a scarred hypovascular environment that does not support free bone grafts well. In addition, there is typically a deficiency in soft tissue that becomes more pronounced when wounds are opened [15].
3. Prolonged hospital stay.
4. Reduction in alveolar ridge height and loss of sulcular depth making future prosthetic rehabilitation difficult and unsatisfactory.

Contemporary, Aggressive, One/Single-Stage, Definitive Management with Immediate Reconstruction

This involves early and aggressive open surgical maxillofacial fixation techniques and reconstructive procedures

carried out hand in hand with the soft tissue debridement and closure. The contemporary paradigm proposes that the first major surgery should be performed with the intent to definitely manage all aspects of the injuries within the first 48 h, and the reconstructive surgery to manage hard tissue, soft tissue or composite defects within the first 7 days [16].

Presently, extensive debridement of soft tissues is not advocated. Wound debris is to be removed and wound should be lavaged with normal saline. A pulsating irrigator is useful to mechanically agitate debris from the tissues. Obviously devitalized and loose teeth should be removed [17]. Salvageable teeth should be retained to aid in future restoration of occlusion and proper jaw relations and of masticatory efficiency. Fractures are reduced and fixed rigidly. Soft and hard tissue defects are reconstructed.

Advantages

1. Reduced post-treatment morbidity.
2. Shorter period of hospitalization.

Fig. 6 **a** Entry point of the bullet from just below the chin. **b, c** Large exit point with exenteration of the right globe with comminuted fracture of the maxilla and mandible with considerable soft tissue avulsion. **d** Schematic depiction of path of the bullet on the CT scan of the patient. **e–h** Patient managed by Initial stabilization; surgical

debridement of unsalvageable soft and hard tissues, immediate open surgical reduction and internal fixation of fractures. **m–p** Early secondary reconstruction of palatal defect and oro-nasal fistula, using palatal advancement flaps, with a satisfactory clinical outcome (Courtesy: Brig SK Roychowdhury, AFMC Pune)

Fig. 7 a–k Late (2 years post-gunshot injury) reconstruction of residual mandibular defect and facial deformity in a Group 2 patient, using free fibular osteomyocutaneous flap. **I** Unsatisfactory esthetic

outcome, with deviation of chin and flattening of lower third of face on the left side. Compromised functional outcome due to difficulty in dental rehabilitation, resulting in impaired masticatory efficiency

3. Reduced number of hospital admissions and lower number of surgeries required to achieve esthetically and functionally satisfactory reconstruction.
4. Early immobilization of fractured bony structures of the face and stabilization of bone segments by means of rigid fixation aid rapid healing of GSWs in this region. Rigid fixation can frequently be maintained even in the event of wound problems, serving to stabilize fractured jaw segments.
5. Percolation of contaminated oral fluids is prevented and primary bone healing is made possible.
6. Reduction in incidence of scar contractures and residual deformities.
7. Immediate reconstruction reduces local dead space, thus enhancing tissue immunoreactivity, robust biological coverage, and expediting wound healing through better access to hematogenous nutrients [18].
8. Early bone grafting stabilizes and supports soft tissues mitigating its subsequent contracture and distortion.
9. Better healing and fewer and less complex surgical revisions than the patients who have undergone delayed surgical reconstructions.
10. Improved ultimate esthetic and functional outcomes.
11. Early return to function and decreased number of revision surgeries are laudable goals.

Disadvantages and Limitations

1. May not be always practically possible.
2. Wound contamination, secondary infection, and poor clinical status often compromise early reconstruction attempts.
3. The main disadvantage of open reduction and rigid fixation is the possibility of infection due to placement of hardware into potentially contaminated tissues.
4. There is high risk of exposure of bone grafts in the region of the mandible, hence immediate bone grafting in this region is best avoided and delayed grafting of mandibular continuity defects is preferable.
5. Free tissue transfers are preferably delayed until after the acute setting to decrease the incidence of flap loss secondary to clotting of the vascular pedicle.
6. There has been reported a high incidence of wound complications in patients undergoing immediate reconstruction of significantly comminuted mandible fractures resulting from GSWs [19].

Combined, Comprehensive, ‘Staged Continuum’ Approach

A combined management approach has recently been proposed by Furan and colleagues [12], which involves a

Table 1 Comparison of esthetic and functional outcomes between groups 1 and 2

S. no	Residual cosmetic deformity Group 1	Residual cosmetic deformity Group 2	Need for repeat/correction surgery Group 1	Need for repeat/correction surgery Group 2	Chronic/recurrent infection at optd site Group 1	Chronic/recurrent infection at optd site Group 2	Reduced masticatory efficiency Group 1	Reduced masticatory efficiency Group 2
1.	N	Y (Mandibular midline deviation to Rt)	N	Y	N	Y	N	Y (Severe malocclusion)
2.	N	N	N	Y	N	N	N	Y (Multiple missing teeth)
3.	N	N	N	Y	N	N	N	N
4.	N	N	N	Y	N	N	N	N
5.	N	N	N	Y	N	N	N	N
6.	N	Y (Flattening of Lt Malar complex)	N	Y	N	N	N	Y (Multiple missing teeth)
7.	N	N	N	Y	N	N	Y (Multiple missing teeth)	Y (Multiple missing teeth)
8.	Y (Flattening of Left lower third of face)	N	Y	Y	N	Y	N	Y (Multiple missing teeth)
9.	N	N	N	Y	Y	N	N	N
10.	Y (Rt Enophthalmos)	N	N	Y	N	N	N	Y (Multiple missing teeth)
11.	N	N	N	Y	N	N	Y (Malocclusion)	N
12.	Y (Flattening of Lt malar complex)	Y (Hypoglobus and Enophthalmos)	N	Y	N	Y	N	N
13.	N	Y ('Andy-Gump facie' with severe mandibular retrusion)	N	Y	Y	Y	N	Y (Severe malocclusion and missing mandibular bone and teeth)
14.	N	N	N	Y	N	N	N	N
15.	N	N	N	Y	N	N	N	N
16.	N	N	N	Y	N	N	N	Y (Multiple missing teeth with loss of alveolar bone height)
17.	N	N	N	Y	N	N	N	N
18.	N	N	N	Y	N	N	N	Y (Multiple missing teeth)
19.	N	Y (Mid-third deficiency)	N	Y	Y	N	N	Y (Malocclusion)
20.	Y (Deviation of chin button to Lt)	N	N	Y	Y	N	Y (Malocclusion)	N

Table 1 continued

S. no	Neurological deficits Group 1	Neurological deficits Group 2	Occlusal discrepancies Group 1	Occlusal discrepancies Group 2	Restricted mouth opening Group 1	Restricted mouth opening Group 2	Impaired speech Group 1	Impaired speech Group 2
1.	Y (Rt infraorbital nerve paresthesia)	Y (Rt Facial nerve LMN palsy)	N	Y (Malocclusion)	N	Y (20 mm)	N	Y
2.	N	N	N	N	N	Y (23 mm)	N	N
3.	N	Y (Lt facial nerve palsy)	N	N	N	Y (25 mm)	N	Y
4.	N	N	N	N	N	N	N	N
5.	N	N	N	N	N	N	N	Y
6.	N	Y (Paresthesia of Lt infraorbital nerve)	N	Y (Deficient dentition)	N	N	N	Y
7.	N	N	Y (Deficient dentition)	N	N	N	Y	N
8.	N	Y (Rt Mandibular nerve paresthesia)	N	Y (Deficient dentition)	N	Y (21 mm)	Y	N
9.	N	N	N	N	N	N	N	N
10.	Y (Rt Infraorbital nerve paresthesia)	N	N	Y (Deficient dentition)	Y (24 MM)	Y (30 mm)	N	N
11.	N	N	N	N	N	N	N	N
12.	N	N	N	Y (Defective dentition)	Y (24 MM)	N	N	N
13.	N	Y (Bilateral Mandibular nerve paresthesia)	Y (Malocclusion)	Y (Malocclusion)	N	Y (15 mm)	N	Y
14.	N	N	N	N	N	N	N	N
15.	N	N	N	N	N	N	N	N
16.	N	N	N	N	N	N	N	N
17.	N	N	N	N	N	Y (23 mm)	N	N
18.	N	N	N	Y (Deficient dentition)	N	N	N	Y
19.	N	N	N	N	N	Y (21 MM)	N	N
20.	N	N	N	N	N	N	N	N

phased approach, albeit with reduced the intervals between the consecutive phases as follows:

- (1) Evaluation and management of the ABCs (establish airway, stop hemorrhage, maintain circulation), life- and limb-threatening injuries, intracranial, ocular, facial nerve, vascular, and other main injuries, excision of all necrotic tissue and maintenance of tissue of questionable prognosis, close lacerations, take impressions for splints, place arch bars for maxillomandibular fixation, maintenance of occlusal relationships, maintaining mandibular segments with reconstructive plates and maxillary defects and soft tissue envelope with temporary bone grafts to avoid later tissue contracture. Preoperative planning for anticipated definitive reconstruction, using 3-D CT scan and stereolithography.
- (2) The second phase involves definitive reconstruction as early as possible, which would entail placement of lingual or occlusal acrylic splints (if indicated), open reduction and internal fixation of those fractures not treated at Stage 1, bone grafts and rotation flaps for tissue coverage as necessary. In severe avulsive wounds, free tissue (hard/soft/composite) transfers are to be considered.
- (3) The third phase focuses on esthetic and functional refinements which may occur over weeks to months in which free flap debulking and contouring [20], dental rehabilitation with implant borne prostheses, facial prostheses, etc., may be done (Figs. 2, 3, 4, 6 and 7).

Conclusion

There has been a meteoric rise in the incidence of cranio-maxillofacial battle injuries despite improvements in body armor, battlefield medicine, tactically placed surgical units and rapid evacuation of casualties. There is a need to develop surgical strategies that can adequately address these esthetically as well as functionally devastating CMF battle injuries and the myriad of long-term deformities that often result from them. There can be no laid down, hard and fast management protocols that would adequately and successfully address all such injuries. Timing and type of surgical intervention would have to be based on individual case to case basis, to best suit the scenario and available expertise and facilities.

Older management protocols in the past advocated delayed definitive treatment using serial debridement and late surgical reconstructions, whereas the more modern and contemporary protocols favor a more immediate definitive surgical reconstruction of soft and hard tissue defects resulting from ballistic injuries. With recent advances in microsurgical techniques have shifted focus from local flap and tissue advancements and have encouraged the use of distant free flap transfers, which improve cosmesis and function. The optimum protocol probably lies somewhere in the middle and has to be based on relevant factors in individual cases rather than restrict oneself to rigidly pre-set algorithms, thus ensuring that the best outcome is achieved. Management principles should more properly be considered as a ‘staged continuum’ that is based on wound,

Table 2 Graphic comparison of evaluated parameters between Groups 1 and 2

Fig. 8 Statistical comparison of residual cosmetic deformity between Groups 1 and 2

Fig. 9 Statistical comparison of requirement for re-surgery between Groups 1 and 2

Fig. 10 Statistical comparison of chronic/recurrent infection at operated site between Groups 1 and 2

Fig. 11 Statistical comparison of neurological deficits between Groups 1 and 2

Fig. 12 Statistical comparison of reduced masticatory efficiency between Groups 1 and 2

Fig. 13 Statistical comparison of occlusal discrepancy between Groups 1 and 2

Fig. 14 Statistical comparison of impaired speech between Groups 1 and 2

Fig. 15 Statistical comparison of restricted mouth opening between Groups 1 and 2

patient, scenario and of surgical expertise, with focus on early, definitive management.

Compliance with Ethical Standards

Conflict of interest The author of this article has not received any research grant, remuneration, or speaker honorarium from any company or committee whatsoever, and neither owns any stock in any company. The author declares that she does not have any conflict of interest.

Research Involving Human Participants and/or Animals All procedures performed on the patients (human participants) involved were in accordance with the ethical standards of the institution and/or national research committee, as well as with the 1964 Declaration of Helsinki and its later amendments and comparable ethical standards.

Ethical Approval This article does not contain any new studies with human participants or animals performed by the author.

Informed Consent Informed consent was obtained from all the individual participants in this study.

Statistical Analysis of Esthetic and Functional Outcomes Between Groups 1 and 2

Statistical Package for the Social Sciences (SPSS) 16.00 for Windows was used to statistically analyze and compare the results between the two Groups. At 95% class interval, following were the observations (the bar on the right in each graph representing the respective Group): (Table 2 and Figs. 8, 9, 10, 11, 12, 13, 14 and 15).

References

1. Saraswat V (2009) Injury patterns in low intensity conflict. *Indian J Anesth* 53:672–677
2. Chen AY, Stewart MG, Raup G (1996) Penetrating injuries to the face. *Otolaryngol Head Neck Surg* 115:464–470
3. Kaufman Y, Cole P, Hollier LH (2009) Facial gunshot wounds: trends in management. *Craniomaxillofac Trauma Reconstr* 2:85–90
4. Anmole O, Osunde O, Akhiwu B (2017) A 14-year review of Craniomaxillofacial Gunshot wounds in a resource-limited setting. *Craniomaxillofac Trauma Reconstr* 10:130–137
5. Gruss JS, Antonyshyn O, Phillips JH (1991) Early definitive bone and soft tissue reconstruction of major gunshot wounds of the face. *Plast Reconstr Surg* 87:436–450
6. Kihitir T, Ivatury RR, Simon RJ et al (1993) Early management of civilian gunshot wounds to the face. *J Trauma* 35:569–577
7. Dolin J, Scalea T, Mannor L et al (1992) The management of gunshot wounds to the face. *J Trauma* 33:508–514
8. Gruss JS, Mackinnon SE, Kassell EE, Copper PW (1985) The role of primary bone grafting in complex craniomaxillofacial trauma. *Plast Reconstr Surg* 15:17–24
9. Cole RD, Browne JD, Phipps CD (1994) Gunshot wounds to the mandible and midface: evaluation, treatment, and avoidance of complications. *Otolaryngol Head Neck Surg* 111:739–745
10. Stuehmer C, Blums KS (2009) Influence of different types of guns, projectiles and propellants on patterns of injury to the viscerocranium. *J Oral Maxillofac Surg* 67:775–781
11. Motamedi MH (2003) Primary management of maxillofacial hard and soft tissue gunshot and shrapnel injuries. *J Oral Maxillofac Surg* 61:1390–1398
12. Clark N, Birely B, Manson PN, Slezak S (1996) High energy ballistic and avulsive facial injuries: classification, patterns and an algorithm for primary reconstruction. *Plast Reconstr Surg* 98:583–601
13. Dufresne CR (1992) The use of immediate grafting in facial fracture management: indications and clinical considerations. *Clin Plast Surg* 19:207–217
14. Thoresby FP, Darlow HM (1967) The mechanisms of primary infection of bullet wounds. *Br J Surg* 54:359–361
15. Dean NR, Mc Kinney SM (2011) Free flap reconstruction of self-inflicted gunshot wounds. *Craniomaxillofac Trauma Reconstr* 4:25–34
16. Deveci M, Sengenzer M, Selmanpakoglu M (1998) Reconstruction of gunshot wounds of the face. *Gazi Med J* 9:47–56
17. Kazanjian VH, Converse JM (1949) Gunshot wounds. In: *The surgical treatment of facial injuries*. Williams and Wilkins, Baltimore, p 78
18. Siberchicot F, Pinsolle J, Majoufre C et al (1998) Gunshot injuries of the face. Analysis of 165 cases and reevaluation of the primary treatment. *Ann Chir Plast Esthet* 43:132–140
19. Vayvada H, Menderes A (2005) Management of close range, high energy shotgun and rifle wounds to the face. *J Craniofac Surg* 16:794–804
20. Furan ND, Farwell DG, Smith RB (2005) Definitive management of severe facial trauma utilizing free tissue transfer. *Otolaryngol Head Neck Surg* 132:75–85