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The Different Surgical Approaches to Maxillofacial Reconstruction after Ballistic Trauma

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Background: Ballistic trauma to the face is a challenge, combining complex bone injury with severe soft tissue loss. The various surgical methods available are influenced by the extent of injuries. This study compares different operative modalities and their outcomes with different variables, aiming to define the ideal therapeutic approach.
Methods: We retrospectively compared reconstructive modalities used to treat facial ballistic trauma cases at Hôtel-Dieu de France Hospital, Beirut, Lebanon, for a 12-year span. Statistical analysis was used to determine correlation between several factors and satisfactory results.
Results: Eighteen patients were included, with varying degrees of bone and soft tissue loss. After conservative debridement, fractures were treated by different modalities: open reduction and internal fixation, maxillomandibular fixation, and osteosynthesis with a reconstruction plate. Although primary closure was sufficient in 10 cases, severe loss of tissues was reconstructed with a fibular free flap in five cases, radial free forearm flap in two cases, and free parascapular flap in one case. Two others received an iliac bone graft as secondary reconstruction. The average follow-up was 2.45 years. Most cases achieved good aesthetic and functional results after several secondary operations, with few late complications. Early reconstruction and younger patients were associated with better outcomes.
Conclusions: We favor early debridement and reconstruction. Free flaps were ideal for extensive tissue loss. Bone grafting was needed secondarily. A single surgical procedure seldom led to satisfactory functional and aesthetic outcomes, and secondary operations were inevitable. *(Plast Reconstr Surg Glob Open 2024; 12:e6066; doi: 10.1097/GOX.0000000000006066; Published online 13 August 2024.)*

INTRODUCTION

Over the past decade, there has been a rising incidence of ballistic trauma, predominantly impacting the male population, where men constitute more than 80% of the reported trauma cases. The face is often primarily involved and presents with a wide range of injuries.[1,2]

Ballistic trauma to the face is considered a severe, life-threatening injury, and the initial care for such patients should prioritize adequate resuscitation using "advanced trauma life support" protocols, with particular attention to bleeding and airway management.[1,3]

Complex facial defects resulting from these traumas have consistently brought new challenges to maxillofacial and reconstructive surgeons.[4,5] The essential characteristic of facial ballistic trauma is combining complex bone injury with severe soft tissue loss.[6] Traditionally, surgeons feared infection and reconstructive failures in such injuries, and therefore opted for conservative treatment, with external fixation and secondary reconstruction.[7]

Many impactful articles later presented case series that concluded in management algorithms leading to better aesthetic and functional outcomes.[6–8] Therapeutic options offered, and their timing, are therefore based on established criteria that consider various factors, such as the trauma's circumstances, whether the weapon involved was a military or civilian one, and the projectile velocity, that is, high versus low.[5–7] Management has then shifted from late to early reconstructions, including early and aggressive debridement, open reduction internal fixation (ORIF), and vascularized free flaps.[6,8] Early management must then be followed by secondary reconstructive procedures on bone and soft tissues to achieve satisfactory aesthetic and functional results.[1,3,5] The aim of our study is to evaluate and compare the different surgical modalities used to treat a series of 18 consecutive patients after sustaining injuries to the face after ballistic trauma, and the optimal timing of surgery.

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Various demographic and historical patient data, including their injury assessments, treatments, and results, are presented and discussed to define the best management plan. We also brought to light patient and management factors related to better aesthetic and functional outcomes.

METHODS

After getting institutional review board approval from the USJ research ethics committee and after accepted ethical standards, we performed a retrospective observational study in our center on 20 patients who were admitted to Hôtel-Dieu de France Hospital (HDF), after gunshot wounds to the face, sustained between 1994 and 2019. We included for analysis all patients who underwent facial reconstructive surgery after ballistic trauma, except for two who died from fatal injuries before any treatment was rendered.

Data were collected from narrative text found in documented assessments, physicians' orders, operative reports, office notes, and radiology reports from medical records of inpatients admitted to HDF, outpatients treated at HDF surgical clinics, and HDF's electronic medical record. Radiographic images and available 3D radiologic reconstructions were also studied. Data collected was anonymized, analyzed, and stored according to HDF's data protection regulations.

The data collected included demographic profiles for all 18 patients. In addition, we collected information on the nature of their initial trauma, the pattern of injury, structural involvement, and the extent of soft tissue and bone loss. In terms of treatment, we collected data on initial management, admission to intensive care unit (ICU), the ICU's length of stay requirements, and early versus late definitive treatment. In the follow-up period, we identified early and late complications after the initial surgery and described surgical revisions aiming to treat complications and/or improve form or function.

Finally, a comprehensive evaluation of the aesthetic and functional outcomes was conducted by the treating surgeon during follow-up visits using a composite scoring system. This scoring system consisted of five key criteria, each graded on a scale from 0 to 1, with a total possible score of 5. The criteria evaluated were (Table 1) (1) symmetry, facial contour, and volume; (2) dental occlusion; (3) chewing, swallowing, and speaking abilities; (4) the psychosocial impact of the reconstruction; and (5) comparisons to preoperative status. A total score of 3 and above was considered a satisfactory result. Subsequently, we correlated this score with diverse patient and management factors.

Takeaways

Question: What are the different operative modalities and their outcomes, considering various variables, used to define the ideal therapeutic approach?

Findings: We retrospectively reviewed and compared various surgical modalities used to treat 18 patients, who had sustained injuries from ballistic trauma, for a 12-year span. Patients presented with varying degrees of bone and soft tissue loss. Our results favor early debridement and reconstruction. When there was extensive soft tissue and bone loss, vascularized osseous free flaps were ideal.

Meaning: The article compares surgical techniques for maxillofacial reconstruction after ballistic trauma, emphasizing that early intervention and the use of free flaps improve aesthetic and functional outcomes.

Statistical analysis was performed using RStudio (version 2022.12.0). The Fisher exact test was used to find any association between satisfaction and the different variables. *P* values of less than 0.05 were accepted as significant.

RESULTS

Demographic Results

Twenty patients sustained ballistic facial injuries requiring maxillofacial reconstruction between 1994 and 2019, two of whom died before treatment. The remaining 18 were all included in this study. The patients were predominantly male (17 of 18; 94%). Mean age was 32 years old. Twelve patients had presented for acute treatment at HDF at the time of acute injury. The others presented later without having received primary treatment at HDF in the acute setting. A total of 55% (10 of 18) of subjects were actively enrolled in the army at the time of their injuries and sustained their injuries while in active duty. The remaining patients were civilians (45%). Ten patients sustained trauma resulting from low-velocity weapons at a close range. Four involved hunting rifles, two involved revolvers, one involved explosive ammunition, and three were caused by unknown weapons. Among the high-velocity cases, two patients were injured by explosion ammunition, two by a sniper shot, and the remaining patients by an unknown weapon. Finally, cases involving civilians were related to firearm accidents, except for one that was due to a failed suicide attempt. There were no

Table 1. Scoring System for Aesthetic and Functional Outcomes

Criterion	Score Description	Score Range
Symmetry, facial contour, and volume	Alignment, proportional balance, and restoration of natural facial features and fullness	0–1
Dental occlusion	Alignment and functionality of the teeth and bite	0–1
Chewing, swallowing, and speaking abilities	Complete oral function (chewing, swallowing, speaking)	0–1
Psychosocial impact	Patient satisfaction and quality of life	0–1
Comparison to preoperative status	Postoperative outcomes vs. preoperative condition	0–1

Table 2. Demographic and Historical Distribution of Patients

N	Age/Sex	Civilian/Military	Date of Trauma	Early/Late Treatment	Mechanism of Injury	Projectile Velocity
1	33/F	Civilian	1994	Late	Direct firearm	LV
2	50/M	Civilian	1997	Late	Direct firearm (HR/SA)	LV
3	29/M	Military	2007	Early	Direct firearm	HV
4	28/M	Military	2007	Early	Shrapnel splinter (EXPL)	HV
5	23/M	Military	2007	Early	Direct firearm	HV
6	39/M	Military	2007	Early	Direct firearm (SS)	HV
7	27/M	Military	2008	Early	Shrapnel splinters (EXPL)	HV
8	37/M	Military	2012	Early	Direct firearm	LV
9	57/M	Civilian	2013	Late	Direct firearm	LV
10	26/M	Civilian	2014	Early	Direct firearm (REV)	LV
11	16/M	Civilian	2015	Early	Direct firearm (HR)	LV
12	39/M	Military	2015	Late	Direct firearm (SS)	HV
13	34/M	Military	2015	Late	Direct firearm	HV
14	52/M	Civilian	2016	Early	Direct firearm (HR)	LV
15	19/M	Military	2017	Late	Direct firearm	HV
16	28/M	Military	2017	Early	Shrapnel splinters (EXPL)	LV
17	26/M	Civilian	2019	Early	Direct firearm (RV)	LV
18	7/M	Civilian	2019	Early	Direct firearm (HR)	LV

EXPL, explosive ammunition; F, female; HV, high velocity; HR, hunting rifle; LV, low velocity; M, male; RV, revolver; SA, suicide attempt; SS, sniper shot.

Table 3. Description and Management of Ballistic Trauma

N	Facial Structures Affected	Loss of Bone or Soft Tissue (B/ST)	Surgery Performed	ICU Length of Stay
1	Frontal bone	B + ST	Free parascapular flap	Yes/24 h
2	Upper L maxillary bone	B + ST	Fibular free flap (fasciocutaneous) + osteotomy	Yes/5 d
3	Comminuted fracture of the R angle of the mandible + fracture of the R orbital floor	B	ORIF	No
4	Maxillary bone + para-symphyseal mandibular fracture	B + ST	ORIF	Yes/6 d
5	L orbital fracture + fracture in the ascending branch of the mandible	ST	ORIF	Yes/7 d
6	Multiple fractures: maxillary, zygomatic bone, mandible	B + ST	ORIF	Yes/6 d
7	Chin tuft	B	Osteosynthesis (reconstructive plates)	Yes/4 d
8	Fracture of the inferior third of the mandible edge	B + ST	Fibular free flap + osteosynthesis	Yes/2 d
9	Lower lip + mandible fracture	ST	Radial free flap + reconstructive plates	Yes/3 d
10	Mandible fracture + maxillary bone + nose dorsum sagging	B	ORIF	Yes/7 d
11	Mandibular symphysis	B + ST	Fibular free flap	Yes/45 d
12	L mandible + L zygomatic bone	B	Osteotomy + iliac bone graft	Yes/2 d
13	Anterior maxillary bone + R orbit bone	B	Iliac bone graft	Yes/7d
14	Multiple fractures: maxillary bone, mandible, zygomatic bone	B + ST	ORIF	Yes/5 d
15	Mandible edge + maxillary bone	B + ST	Radial free flap + bone graft	Yes/3 d
16	R mandible + R maxillary bone	B + ST	Fibular free flap + skin pectoral flap + orbital bone graft	No
17	L comminuted fracture of the mandible	B	Maxillomandibular fixation	Yes/3 d
18	Mandible: right angle + left body	B + ST	Fibular free flap	Yes/11 d

B, bone; L, left; R, right; ST, soft tissue.

homicide cases. An overview of the demographic and historical data collected is provided in Table 2.

Injury Assessment and Surgical Management

Twelve patients who presented to the emergency department were stabilized according to the "advanced trauma life support" protocol. They were evaluated by x-rays and three-dimensional computed tomography reconstructions. Of these 12 cases, eight required emergency tracheostomy after hemostasis (Table 3).

All the injuries were limited to the face; 10 patients presented with comminuted fractures of the facial bones, especially to the mandible and maxillary bone, with an extensive loss of bone substance and soft tissue. Six patients

Fig. 1. Case 1: reconstruction of soft tissue loss with radial free flap. This case presents a patient who sustained ballistic trauma to the lower face resulting in significant soft tissue loss to the lower lip. Reconstruction was performed using a radial free flap. A, Preoperative presentation. A preoperative photograph depicting the patient with multiple scars and a severe soft tissue defect involving the lower lip. B, Postoperative outcome (3 months). A photograph taken 3 months postoperatively, demonstrating successful reconstruction of the lower lip with a radial free flap, resulting in restoration of oral competence and aesthetic continuity of the lower face. C, Intraoperative procedure. An intraoperative photograph showcasing the harvesting of the radial free flap.

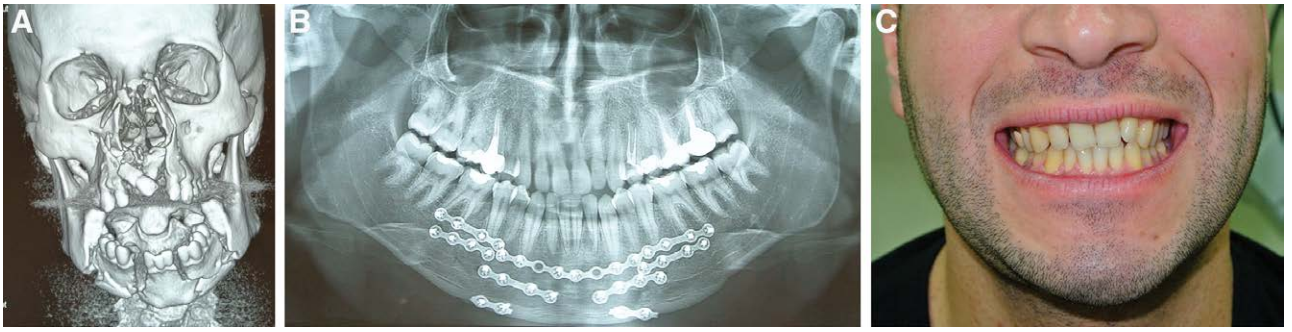

Fig. 2. Case 2: conservative management of isolated bone fractures. This case represents a patient with isolated fractures of the mandible, maxilla, alveolar processes, and nose after ballistic trauma. The fractures were managed conservatively without significant soft tissue involvement or loss. A, Three-dimensional computed tomography scan illustrating the multifocal fractures involving the mandible, maxilla, alveolar processes, and nose. B, Panoramic radiograph demonstrating successful reduction of fractures after early debridement and osteosynthesis, indicating proper alignment and stability of the affected bone structures. C, Clinical outcome. A photograph taken 6 months postoperatively showcasing the patient's favorable occlusion and aesthetic outcome achieved through conservative management.

had a large loss of bone substance, of which three cases were associated with segmental loss in the mandibular symphysis. Two others had injuries in the maxillary bone, and only one had a sequela in the frontal bone. Two patients had only soft tissue loss, of which one presented with total loss of the lower lip (Fig. 1). Aside from the six cases complicated by large loss of bone substance, all patients who presented to the emergency department underwent early reconstruction. Soft tissue conservation, meticulous debridement, and preservation of viable teeth were aimed for primarily. Comminuted fractures were fixed by microplates and screws in six cases (ORIF) (Fig. 2). One case required the use of reconstruction plates (Fig. 3). Another case was treated by a bimaxillary blockage (maxillomandibular fixation) by steel arches and wires.

No nonvascularized bone grafts were performed as first-line treatment. In four cases, the loss of bone and soft tissue was so significant that it warranted the use of a fibular free flap, and mandibular reconstruction plates were used (Fig. 4). Primary closure in 11 cases was sufficient to cover soft tissue loss. However, the skin part of the fibular free flaps was used to reconstruct the loss of soft tissue in three cases. Finally, concerning the six cases of large bone loss, one patient was treated by a free parascapular flap, one with a free fibula flap, and two with a radial free flap. In two other cases, the loss of bone material was moderate; thus, a nonvascularized bone graft was used in a secondary reconstruction. Postoperatively, 16 patients were admitted to the surgical intensive care unit with an average duration stay of 7.3 days, and a median of 5 days.

Complications and Secondary Revision

Patients were followed up for an average of 2.45 years (6 months to 7 years). All patients were evaluated postoperatively to ensure the quality of the functional and aesthetic reconstruction (chewing, occlusion, articulation, and symmetry of the face) (Table 4).

We noted five cases of early complications such as operative site infection. Four were treated conservatively with adequate antibiotic coverage, and one patient experienced

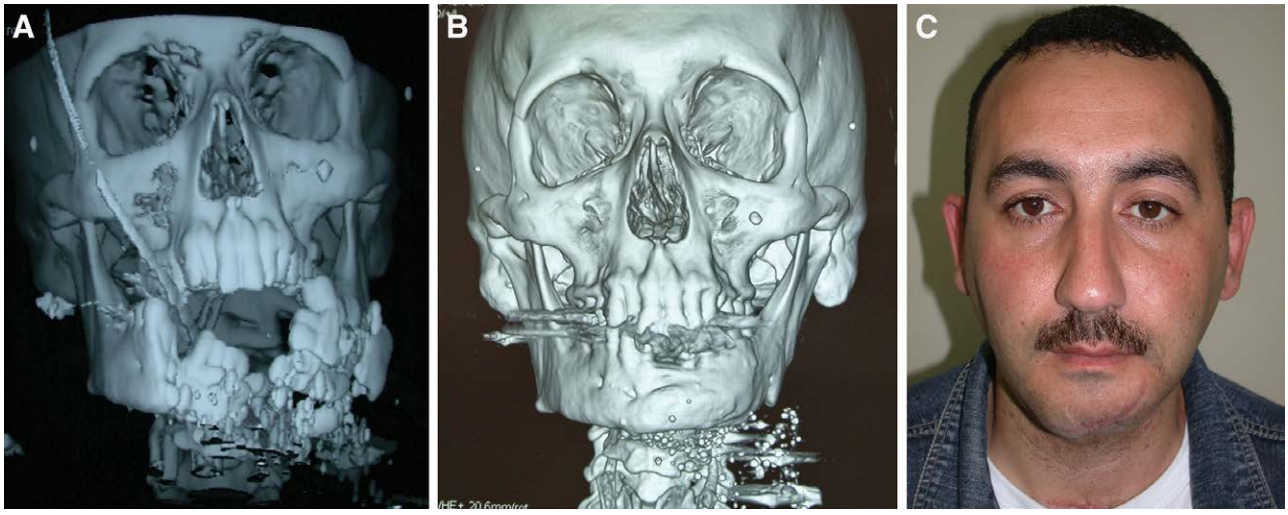

Fig. 3. Case 3: management of mandibular fracture with osteosynthesis and secondary bone grafting. This case involves a patient with mandibular fractures treated initially with osteosynthesis using a reconstructive plate. Subsequently, the patient developed pseudarthrosis, necessitating secondary bone grafting. A, Preoperative three-dimensional computed tomography scan depicting the comminuted fracture of the mandible before initial osteosynthesis, highlighting the complexity of the injury. B, Postoperative three-dimensional computed tomography scan demonstrating complete healing of the mandibular fracture after secondary bone grafting, with removal of the reconstructive plate, indicating a successful resolution of pseudarthrosis. C, Postoperative clinical outcome. A photograph depicting the patient's favorable outcome after reconstruction, showcasing restored facial symmetry and function after resolution of the mandibular pseudarthrosis.

a loss of the bony part of the flap. One free flap showed arterial compromise postoperatively, which required revision of the anastomoses on day 1 postoperatively. A free fibula flap was lost due to thrombosis of its pedicle.

Fifty percent of patients progressed favorably without late complications. Among the other half who had late complications, we noted a callus with disorder of the temporomandibular joint and rupture of the osteosynthesis plate. Suffering of the end of the flap happened in two cases, one of which also had a pseudarthrosis which required a secondary bone graft (Fig. 3). One patient had calcification of the pedicle of the fibula flap requiring removal of the osteoma, whereas another patient experienced salivary incontinence. One case of nasal synechia was noted, and finally, two patients had recurrent osteitis.

We could note several rehospitalizations for several secondary procedures, with an average of three hospitalizations. Most of the patients (89%) were readmitted for surgical material ablation. One patient required several skin remodeling procedures of the flap. In another case, a radial free flap was used to reconstruct the lower lip. Three patients underwent a labial Z-plasty, and one patient required a vestibuloplasty to contain hyper salivation. Two other patients underwent a rhinoplasty, and seven patients received a second-line bone graft. One patient needed a bone graft for rehabilitation and dental implants. We noted several secondary interventions for the release and repair of scar bands in five cases.

Aesthetic and Functional Result, and Correlated Factors

Most patients had significant improvements on the aesthetic and functional levels. Based on the composite scoring system used by the treating physicians, 11 (61%) patients had satisfactory aesthetic and functional results (score of 3 and above) (Tables 5, 6).

In our analysis, we found that individuals 35 years of age or younger exhibited higher satisfaction scores (P = 0.0128). Half of the military personnel achieved satisfactory results, whereas most civilians experienced satisfactory outcomes (75%), but no statistically significant association was found between status (civilian/military) and satisfaction (P = 0.3665). Smokers tended to have slightly worse results (P = 0.1448). High-velocity trauma showed evenly distributed outcomes, whereas low-velocity trauma demonstrated better overall results (P = 0.6305). No association was found between injury (simple/combined) and satisfaction (P = 1).

When examining management factors, a significant majority of patients treated early (83.3%) exhibited superior results, whereas the opposite trend was noted for those undergoing late reconstruction (P = 0.0128). No association was found between the use of free flaps and satisfaction (P = 0.6305). No significant difference in results was observed with different numbers of days spent in the ICU (P = 0.6305). The presence or absence of early complications showed very similar percentages of satisfactory results (62.5 versus 60%, P = 1). The same was applicable with the presence or absence of late complications (P = 1). No association was found between the number of hospitalizations and satisfaction (P = 1).

DISCUSSION

Major ballistic trauma to the face is a common presentation.[1,9] The most frequent causes of face

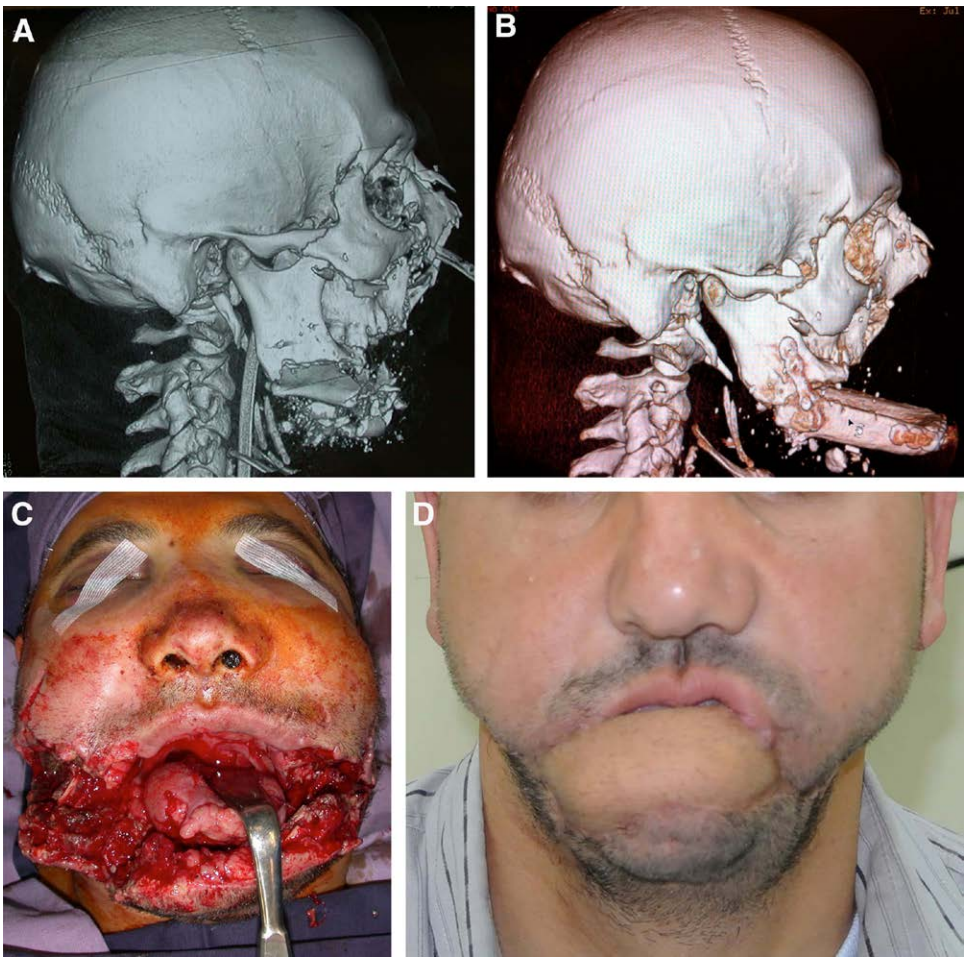

Fig. 4. Case 4: reconstruction of complex soft tissue and bone loss with free fibular flap. This case involves a patient who sustained complex soft tissue and bone loss to the lower face after trauma. Reconstruction was performed using a free fibular flap. A, Preoperative three-dimensional computed tomography scan illustrating the extensive bone loss involving the lower face in the patient after trauma. B, Postoperative three-dimensional computed tomography scan demonstrating successful reconstruction of the lower face with a free fibular flap, highlighting the restoration of facial contour and volume. C, Preoperative clinical presentation. A photograph showing the preoperative extent of soft tissue loss in the lower face, indicative of the severity of the traumatic injury. D, Postoperative outcome. A postoperative photograph illustrating the successful coverage of soft tissue loss with the skin paddle of the free fibular flap, showcasing the restoration of facial aesthetics and function.

ballistic trauma are wounds endured during military service, accidents, homicides in civil society, and suicide attempts.[9–11] The immediate mortality rate from these traumas, especially the upper face, is high. The injured patients who have nonfatal wounds survive mostly thanks to immediate on-site care, which is continued in the emergency room, often needing intubation, or even a tracheostomy.[1,12,13] The extent and severity of the lesions depend primarily on the type of weapon used, with major trauma resulting from high-velocity or low-velocity weapons with a blast effect, such as a shotgun.[14–16] The lesions can range from a simple displaced fracture (it is especially the case of low-velocity handgun bullets), to comminuted fractures with loss of major bone and soft tissue substances.[2,11,17] The initial goal of the surgical management of fractures is to restore the continuity and stability of the mandibular arch and to preserve the skin and mucous membranes as much as possible, aiming to restore the function and symmetry of the face.[5,18,19]

Early surgical treatment is currently recommended. It includes initial debridement to thoroughly cleanse wounds, remove necrotic tissue and debris, and save viable tissue.[4,15,20–22]

After a good debridement, the next step is to reduce and stabilize the fractures. Therefore, a large arsenal of varied techniques is available, ranging from simple bimaxillary fixation to open reduction and internal fixation by semirigid plates or reconstruction plates.[12,18,23] Likewise, it is easier to manipulate and change the shape of the

Table 4. Patient Follow-up and Complications

N	Follow-up Duration	Early Complications	Late Complications	Secondary Interventions	No. Hospitalizations
1	3 y	Arterial compromise of free flap	Distal flap necrosis	Multiple defatting and advancement	6
2	8 mo	X	Ossification of the flap pedicle	Material ablation + ossification resection	3
3	2 y	X	Vicious cal of the dental articulation + fracture of osteosynthesis plate	Material ablation	2
4	4 y	Fever and chills	X	Maxillary and parietal bone graft for dental rehabilitation + scar revision for scar contracture	4
5	7 y	Transient facial nerve palsy	Left nasal synechia	Material ablation + scar revision of the nasal wing + lipofilling 15 mL	3
6	3 y	X	X	Material ablation	2
7	2 y	X	Osteitis and pseudarthrosis	Secondary iliac bone graft	3
8	2 y	X	Salivary incontinence	Lower lip reconstruction + turbinectomy + scar revision + material ablation	4
9	2 y	X	X	X	1
10	2 y	X	Fibrous adhesions + nose asymmetry	Rhinoplasty + fibrous adhesions repair	2
11	5 y	Fibular flap loss	Pseudarthrosis	Latissimus dorsi flap + bone graft	4
12	2 y	Recurrent osteitis and cellulitis	Actinomyces	Multiple debridement + Iliac bone graft + material ablation	7
13	2 y	Decreased right V2 sensibility	X	Iliac bone graft	7
14	2 y	Recurrent fever	X	Radial free flap for lower lip reconstruction + lip Z-plasty + nasal reconstruction	2
15	2 y	Flap congestion	X	Bone graft + vestibuloplasty	3
16	3 y	X	X	X	1
17	4 mo	X	X	Material ablation	1
18	4 mo	X	X	X	1

Table 5. Patient and Trauma Factors Related to Satisfactory Results

Patient and Trauma Factors	Unsatisfactory Result (0–2), N (%)	Satisfactory Result (3–5), N (%)
Age, y		
<35	2 (16.7)	10 (83.3)
>35	5 (83.3)	1 (16.7)
Status		
Civilian	2 (25)	6 (75)
Military	5 (50)	5 (50)
Smoking		
Smoker	5 (62.5)	3 (37.5)
Nonsmoker	2 (20)	8 (80)
Velocity		
High	4 (50)	4 (50)
Low	3 (30)	7 (70)
Simple or combined injuries		
Bone or soft tissue	3 (37.5)	5 (62.5)
Bone and soft tissue	4 (40)	6 (60)

miniplates to have the best possible reduction. However, rigid reconstruction plates are essential in bridging the space between bone stumps while preventing soft tissue retraction.[17]

In the case of a significant loss of bone material, nonvascularized bone grafts are not recommended in primary reconstruction, as they have a high failure rate with a significant risk of infection.[1,17] This was the case in two of our patients who presented with a sequela after a ballistic trauma initially operated on by a placement of a nonvascularized bone graft, which ended in loss of the graft.

If immediate reconstruction of extensive bone loss is needed, the bone free flap is the ideal solution.[12,24] This was the case in four of our patients. The use of computer-assisted flap modeling, which represents a major advance in the preparation of bone flaps and their osteotomies, was not possible in our series due to lack of resources. In the literature, several types of flaps are described, such as the free fibula, scapula, and iliac crest flap, but currently, the free fibula flap is the cornerstone of primary bone reconstruction of the face, especially of the mandible.[17,25] This type of flap has several advantages, as it offers a very long and wide bone, good vascularization with a

Table 6. Management Factors Related to Satisfactory Results

Management Factors	Unsatisfactory Result (0–2), N(%)	Satisfactory Result (3–5), N(%)
Early vs late treatment		
Early	2 (16.7)	10 (83.3)
Late	5 (83.3)	1 (16.7)
Use of free flaps		
With free flap	4 (50)	4 (50)
Without free flap	3 (30)	7 (70)
Length of stay in the ICU, d		
≤3	4 (50)	4 (50)
>3	3 (30)	7 (70)
Acute complications		
Presence	3 (37.5)	5 (62.5)
Absence	4 (40)	6 (60)
Late complications		
Presence	3 (33.3)	6 (66.7)
Absence	4 (44.4)	5 (55.6)
No. hospitalizations		
Single	1 (25)	3 (75)
Multiple	6 (42.8)	8 (57.2)

long pedicle, and the possibility of multiple osteotomies due to its double intramedullary and periosteal vascularization.[17] The only disadvantage of this flap is that the soft tissue component is not significantly bulky and has a fragile vascularity.[17] Microsurgical reconstruction carries a risk of thrombosis of the anastomoses and loss of the flap, which was the case in one of our patients who required a second rescue musculocutaneous flap.

Alternative methods can be used in case the patient has significant soft tissue loss.[21,26] If the primary closure is not sufficient to recover the soft tissue loss after good debridement, most cases require cover flaps, as in one of our cases where a free radial antebrachial flap was used to reconstruct the lower lip. In the literature, the free flap of the gracilis muscle has shown interesting functional results for this special indication.[27] In extreme cases, the option of facial transplantation remains a possibility despite its technical, ethical, and immunological problems.[28]

To optimize the functional and aesthetic results and to treat any secondary complication, one or more secondary procedures will be necessary in almost all cases.[11,14,15,29] The vast majority of our patients benefited from secondary interventions, some of which were performed to treat complications such as pseudarthrosis, vicious callus, salivary incontinence, and microstomy, or to remove an ossified pedicle, and others were done to improve appearance (eg, hypertrophic or retracted scars), or to allow dental fitting and placement of dental implants.

Regarding complications, a major finding to note in our study is that the more severe the lesion assessment, the more likely that patients will have a high complication rate. Finally, because the complication rate in our study was independent of the surgical modality used, we cannot conclude whether one treatment is better than the other.

When comparing outcomes of our reconstruction cases, we had significantly better reconstruction outcomes in younger patients, and part of the explanation is the better healing process in such patients and the potential of tissue adaptation and integration of grafts, flaps, and internal fixation material. Early reconstruction was the second significant factor. Our study also reinforces the importance of early debridement after facial ballistic trauma. Although this principle is well established in reconstructive surgery, our findings underscore its critical role in achieving optimal outcomes for patients. Additionally, our analysis highlights the multifaceted nature of facial reconstruction, encompassing not only the restoration of physical appearance but also the function and profound impact on patients' psychosocial well-being.

Although existing literature supports the advantage of early bone grafting postdebridement and soft tissue coverage, our findings elucidate that in the cases examined, challenges such as compromised vascularization at the recipient site, infections, and other complicating factors hindered the application of bone grafts in the early phases of reconstruction. Consequently, bone grafts were deferred to later reconstructive stages, where they were successfully utilized, resulting in favorable outcomes.

Status (civilian/military), smoking, velocity, complexity of injury, use of free flaps, length of ICU stay, presence of acute or late complications, and the number of hospitalizations had no significant impact on final outcomes.

LIMITATIONS

Although the majority of our cases have shown favorable outcomes, our study is constrained in its analysis of postoperative results. Given its retrospective nature, we depended on the treating surgeon's assessment to evaluate both functional and aesthetic outcomes, utilizing a composite scoring system. However, it is essential to note that this scoring system lacks standardization and does not cater to specific measures of functional outcomes, such as occlusion in patients. This limitation could potentially lead to a misrepresentation and an underestimation of the incidence and varying degrees of malocclusion.

In addressing the timing of bone grafting, we recognize the constraints of our study, which stem from the limited number of cases needing bone grafts analyzed. This small sample size may restrict the broader applicability of our findings, highlighting the necessity for additional research with larger cohorts to validate and augment our observations.

The images and radiographic studies featured in this article were obtained from archival sources, and obtaining digital copies posed a challenge. The majority of patients sought treatment at our center before the implementation of digital archiving for medical imaging.

CONCLUSIONS

The therapeutic approach to facial ballistic trauma is a real challenge, given the great variability of the presentations that arise. This is a multidisciplinary care, because in most cases, the lives of patients are at stake. Basic resuscitation is always necessary for stabilization of patients, after which the primary reconstruction can begin. Our study showed significantly better reconstruction result in patients with early reconstruction, reinforcing the importance of this well-established principle in the light of aesthetic, functional and psychosocial results. The fractures are fixed by semirigid plates or by reconstruction plates in the case of loss of continuity of the mandible. Despite evidence suggesting that bone grafts should be performed in earlier stages, our cases demonstrate that they can yield favorable outcomes when applied secondarily, where feasible. Our findings affirm the effectiveness of the free fibula flap as the preferred option for reconstructing extensive bone loss resulting from facial ballistic trauma. Likewise, the first microsurgical reconstruction is often the most suitable solution for extensive loss of substances in soft tissues. Nevertheless, the expertise and the clinical judgment of the surgeon plays a major role in the choice of treatment. Finally, in this kind of complex trauma, we noted that a single surgical procedure was not enough to have a satisfactory result. When aesthetics and function are intertwined, multiple surgical procedures are necessary over a long period, which can be up to several years.

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DISCLOSURE

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

ETHICAL APPROVAL

Ethical approval was obtained from the Saint Joseph University research ethics committee.

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