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Reconstruction of firearm and blast injuries in Syrian war refugees

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Abstract

Background: War injuries differ from other injuries owing to the large tissue defects they cause and their high risk of contamination. As fragments scattered by high-energy firearms and explosives cause serious composite tissue damage, repair of such injuries is difficult and requires a long treatment period. We discuss the treatment methods used for injured Syrian War refugees admitted to our clinic and present the most effective repair methods for war-related tissue defects for each region of the body.

Methods: A total of 61 patients treated between June 2012 and April 2015 were retrospectively evaluated in terms of age, gender, duration of hospitalisation, injury site and repair method employed. The patients were grouped by region injured (head/neck, extremities and trunk).

Results: The female-to-male ratio of the patients was 16/45, and their mean age was 25.2 (range, 3-51) years. Twenty-two patients were under the age of 18. The mean duration of hospitalisation was 28.5 days. A total of 130 operations were performed on the patients, including debridement and revisions. Repairs were conducted with free flaps in 17 patients (6 on the head/neck region, 11 on extremities) and with pedicle flaps in 28 patients (11 on the head/neck region, 12 on extremities, 5 on the trunk). Two patients experienced flap loss without other complications, and other patients experienced complications including bleeding, infection, flap detachment, hematoma and seroma.

Conclusions: War injuries cause tissue damage of a composite and extensive nature. Most affect the extremities, followed by the head/neck and trunk regions. They are primarily sustained by the young population, not usually easy to treat, and require long hospitalisation periods. A variety of methods may be preferred to treat these injuries.

1 | INTRODUCTION

Soft tissue and skeletal injuries are frequently encountered by plastic surgeons and may require simple or complicated operations depending on the case. These injuries may have many different causes, of which firearms and shrapnel are among the most notable, as they cause extensive tissue damage because of high-energy trauma.

Great wars in history have always brought about advances in surgery. The American Civil War in the 1860s led to improvements in leg amputation techniques, World War I led to advances in the treatment of craniofacial injuries, World War II saw advances in

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treatment protocols for hand burns, and the Vietnam War drove improvements in the repair of major vascular injuries.[1]

High-energy firearms and explosives have become increasingly sophisticated, especially in the last 100 years, and are today the main weapons of war. Shrapnel (fragments scattered by explosives) is now the most common cause of war-related injuries. Repair of firearm and shrapnel injuries requires massive and lengthy effort, as they involve severe composite tissue damage. No standard protocol exists for the treatment of such injuries; however, the best treatment is considered to involve early debridement and repairs with vascularised tissue, depending on the experience of the surgeon.[2]

This article describes the modern and effective reconstruction methods we used to treat Syrian War refugees with high-energy firearm injuries who presented to our clinic for treatment, with the aim of assisting the reader in handling similar cases.

2 | METHODS

A total of 61 refugee patients who sustained high-energy firearm injuries in the Syrian War between June 2012 and April 2015 were evaluated retrospectively. The sample consisted of patients who underwent operation after they were admitted to our clinic, to our hospital's emergency room, or to other clinics and intensive care units.

Patients with head/neck, extremity, and trunk injuries were enrolled in the study upon the approval of the local ethics committee and in compliance with the Declaration of Helsinki. Patients who underwent elective operations, did not undergo operation, or were treated in the burn centre were excluded from the study. The enrolled patients were evaluated in terms of age, gender, duration of hospitalisation, injury site and repair method employed. Time intervals between injury and admission to the hospital could not be determined because of the language barrier and difficulties in obtaining reliable information.

Patients who did not require urgent operation were treated with a wound care protocol using antibiotic-impregnated dressing or negative pressure wound therapy (VAC Therapy System; KCI, San Antonio, Texas). Appropriate steps such as debridement, dressing and washing were taken to ensure proper wound hygiene before flap repair.

3 | RESULTS

Of the 61 patients included in the study, 16 (26.22%) were female and 45 (73.77%) were male. The age range of the patients was 3 to 51 years (mean 25.2). A total of 130 operations, including debridement and revisions, were performed. Most patients underwent operation more than once. Thirty patients had extremity injuries (upper in 11 and lower in 19), 24 had head/neck injuries, 4 had trunk injuries, 2 had both lower extremity and trunk injuries, and 1 had upper and lower extremity and trunk injuries (Table 1). Twenty-two patients were under the age of 18 (10 male, 12 female), and 39 were over 18 (35 male, 4 female; Table 2).

TABLE 1 Distribution of defects by localisation

Localisation	Number	Percentage (%)
Extremity	30	49.2
Head/neck	23	37.7
Trunk	4	6.5
Lower extremity and trunk	2	3.3
Upper and lower extremity and trunk	1	1.6
Head/neck and trunk	1	1.6
Total	61	100

TABLE 2 Patient demographics

	Male	Female	Total	Percentage (%)
Under 18	10	12	22	36.1
Over 18	35	4	39	63.9
Total	45	16	61	100

Free flap operations were performed on 17 patients; six of the flaps were applied to the head/neck region, the other 11 to the extremities. Pedicle flaps were used for 28 patients; 11 were applied to the head/neck region, 12 to the extremities, and 5 to the trunk. Both free and pedicle flaps were used to treat patients 6, 9, 14 and 23. Open reduction and internal fixation operations were performed on facial bone fractures in a total of six patients, of whom two were children; four had panfacial fractures (nasal, orbital, maxillary Le Fort II and III), and two had mandibular fractures. The number of patients who underwent only debridement and skin graft or suturation was 14 (Table 3). The mean duration of hospitalisation was 28.5 days (range 5-129 days): 30.3 days (range 10-123 days) for patients with extremity injuries, 20.7 days (range 5-56) for patients with head/neck injuries and 47.5 days (range 18-129) for patients with trunk injuries. (For mean calculation purposes, patients 6, 21 and 39, who had multiple traumas, were included in the trunk group, and patient 43 was included in the head/neck group.) The mean duration of hospitalisation for the 11 patients with upper extremity injuries was 28.9 days; for the 19 lower extremity patients, it was 31.1 days.

Two patients experienced flap loss, though no other major complications; one had been treated with a free gracilis flap, the other with a free anterolateral thigh (ALT) flap. Other complications included bleeding, secondary infection, flap detachment, hematoma and seroma. The complications were treated by secondary interventions.

3.1 | Case reports

3.1.1 | Patient 5

A 19-year-old male patient was hospitalised because of blast injury on the dorsal aspect of the right foot. At the time of presentation,

TABLE 3 Clinical characteristics and operations performed

Patient	Age	Gender	Hospitalisation time (days)	Localisation/defect	Flap type/operation	Number of operations
EXTREMITY						
1	34	M	18	Cruris (distal 2/3)	Free musculocutaneous LD	1
2	22	M	12	Dorsal right hand, metacarpals 2 and 3	Free osteocutaneous fibula	2
3	33	M	33	Left tibia (medial 1/3)	Free osteocutaneous fibula	2
4	13	M	71	Cruris (distal 2/3)	Free musculocutaneous LD (cross-leg)	5
5	19	M	20	Right foot and ankle	Free ALT flap	1
6	10	F	48	Anterior thigh and femur	Free osteocutaneous fibula	2
7	30	F	64	Skin of dorsal left hand (11 × 12 cm); 2nd, 3rd, and 4th metacarpals	1. Free osteocutaneous fibula 2. Composite groin flap (with iliac bone)	4
8	15	F	14	Left cruris (distal 1/3) and ankle	Free ALT flap, STSG	1
9	27	M	21	Cruris (distal 1/3) and foot	Free ALT flap	1
10	25	M	123	Cruris (medial, distal 1/3)	1. Free ALT flap (fail) 2. Cross-leg reverse pedicle sural fasciocutaneous flap	7
11	4	M	12	Elbow	Posterior interosseous fasciocutaneous flap	1
12	41	M	13	Cubital	Radial collateral artery perforator flap	2
13	11	F	38	Dorsal hand	Pedicle groin flap	3
14	51	M	21	Right posterior arm (distal 1/3)	Musculocutaneous LD	2
15	28	M	19	Right cruris (medial 1/3)	Soleus muscle flap	1
16	38	M	44	Dorsal right hand	Pedicle groin flap	4
17	5	F	30	Foot and ankle	Reverse pedicle sural fasciocutaneous flap	3
18	48	M	23	Cruris (superior 1/3)	Gastrocnemius muscle flap	1
19	16	M	56	Dorsal hand skin	Pedicle groin flap	4
20	21	M	10	Cruris (distal 1/3)	Peroneal perforator flap	1
21	5	F	32	Cruris	Debridement/skin graft	3
22	10	F	11	Forearm	Debridement/skin graft	1
23	10	M	30	Cruris	Debridement/skin graft	3
24	20	M	24	Cruris	Debridement/skin graft	3
25	44	M	20	Leg	Debridement/skin graft	1
26	12	F	18	Popliteal	Debridement/skin graft	2
27	45	M	37	Arm/amputation	Debridement/skin graft	4
28	15	F	10	Wrist	Debridement/skin graft	1
29	41	M	13	Foot	Debridement/skin graft	1
30	32	M	25	Cruris	Debridement/skin graft	4
HEAD AND NECK						
31	48	M	21	Left mandible (soft tissue and bone)	Free osteocutaneous fibula	2
32	35	F	29	Temporoparietal scalp defect (27 × 21 cm)	Free LD muscle	1
33	21	M	56	Total lower lip and mentum (soft tissue defect)	1. Free gracilis muscle (fail) 2. Bipedicle scalp flap	4
34	23	M	36	Left mandible (soft tissue and bone)	Free osteocutaneous fibula	2
35	30	F	19	Left hemifacial soft tissue defect	Free ALT flap	1

(Continues)

TABLE 3 (Continued)

Patient	Age	Gender	Hospitalisation time (days)	Localisation/defect	Flap type/operation	Number of operations
36	46	M	45	Anterior maxilla and upper lip defect	Free osteocutaneous fibula	4
37	28	M	13	Temporoparietal defect (12 × 6 cm)	Scalp flap	1
38	34	M	16	Orbitozygomatic soft tissue and bone defect	Temporal muscle flap, STSG	1
39	51	M	19	Neck (15 × 7 cm)	Pectoral muscle flap, STSG	2
40	9	M	12	Frontoparietal defect (8 × 6 cm)	Scalp flap	1
41	37	M	12	Frontoparietal defect (12 × 8 cm)	Scalp flap	1
42	33	M	24	Head and neck (soft tissue defect, 12 × 9 cm)	Pectoral musculocutaneous flap, STSG	2
43	24	M	14	Anterolateral neck	Transverse cervical artery perforator flap	1
44	10	M	18	Anterolateral neck	Deltopectoral fasciocutaneous flap	2
45	4	F	11	Anterolateral neck	Transverse cervical artery perforator flap	1
46	21	M	12	Frontoparietal	Pedicle scalp flap	1
47	22	M	5	Mandible region	Debridement/suturation	1
48	3	F	14	Scalp	Debridement/skin graft	1
49	17	M	28	Panfacial fracture, neck	Rigid fixation, local flaps, STSG	2
50	51	M	15	Panfacial	Rigid fixation	1
51	22	M	14	Mandible	Bone graft, rigid fixation	1
52	27	F	21	Panfacial	Rigid fixation	1
53	28	M	5	Mandible	Rigid fixation	1
TRUNK						
54	34	M	38	Inguinal soft tissue defect (18 × 15 cm)	İnferior pedicle rectus abdominis muscle flap	3
55	15	F	44	Inguinal defect (15 × 10 cm)	Pedicle ALT flap	4
56	23	M	18	Inguinal	Debridement/skin graft	2
57	12	M	22	Inguinal	Debridement/suturation	1
MULTIPLE ANATOMIC REGION						
58 (6)	41	M	129	Left inguinal area and leg, right forearm, dorsal penis	1. Free TDAP 2. İpsilateral rectus muscle	8
59	11	F	23	Left inguinal area and distal thigh (soft tissue defect)	Inferior pedicle rectus abdominis muscle flap, STSG	2
60	12	M	(129) 59	Left inguinal and cruris	Pedicle ALT flap, STSG	3
61	8	M	39	Panfacial, abdominal soft tissue defect	Rigid fixation, STSG	1

Abbreviations: ALT, Anterolateral thigh; LD, latissimus dorsi; STSG, split-thickness skin graft.

the 2nd, 3rd and 4th toes of the right foot had been totally amputated and the 5th toe had been partially amputated, and a defect of 25 × 13 cm was observed, exposing the extensor tendons (Figure 1A). A free ALT flap was prepared for the patient following debridement, and end-to-end anastomosis was applied to the tibialis anterior artery and vein (Figure 1B,C). A part of the defect was simultaneously repaired with a split-thickness skin graft (Figure 1D). The flap donor site underwent primary repair. The patient was discharged without any complications.

3.1.2 | Patient 58

A 41-year-old male patient with extensive tissue loss because of blast injury had a 20 × 32 cm defect exposing the femoral artery and vein in the left inguinal area, as well as a 5 × 4 cm defect in the dorsal aspect of the penis. His left leg had been amputated above the knee, his right arm had been amputated below elbow and he had a very thin soft tissue coverage over the amputation stump of the



FIGURE 1 Defect in the dorsal aspect of the right foot. A) preoperative appearance of the foot defect B) harvested anterolateral thigh flap C) completed microvascular anastomosis D) postoperative appearance of the foot

right forearm, which not suitable for prosthesis. The amputation, as well as repair of the proximal femur fracture, had been performed in another hospital. Following soft tissue debridement, the defect in the inguinal area was covered ipsilaterally with a rectus abdominis flap, while the penis was covered with a random fasciocutaneous flap prepared from the pubic area (Figure 2A). The inguinal area was repaired with a skin graft following regular dressing applications. The pedicle of the flap applied to the penis was removed after 3 weeks (Figure 2B,C). A free thoracodorsal artery perforator flap of 19 × 15 cm was prepared to repair the amputation stump of the right forearm, and end-to-end anastomosis was applied to the ulnar artery and vein (Figure 2D-F). One week later, flap advancement was repeated, and the patient was discharged in a condition suitable for prosthesis fitting (Figure 2G).

3.1.3 | Patient 34

A 48-year-old male patient was hospitalised because of firearm injury. A soft tissue and mucosal defect of 6 × 4 cm was observed in the left mandibular region, and direct X-ray showed bone defect in the mandibular corpus and ramus (Figure 3A,B). Following debridement, the mandible was repaired using a free 15 cm osteocutaneous fibula flap with single osteotomy (Figure 3C,D). The mucosa was repaired with the skin of the flap. The defect was sutured; unfortunately, the patient suffered suture detachment in his mouth after the surgery. Mentioned complication was managed with secondary suturation under local anaesthesia. The patient was discharged on a liquid diet with an opportunity of dental restoration with implants in late period.

3.1.4 | Patient 7

A 30-year-old male patient had a firearm injury in the dorsal aspect of his left hand. He had a defect in the soft tissue covering the entire dorsal aspect of his hand, as well as bone and extensor tendon loss in the 2nd, 3rd and 4th metacarpals (Figure 4A). Following debridement, the skin and metacarpals were repaired with a free osteocutaneous fibula flap, and the skin was further repaired with a split-thickness skin graft (Figure 4B-E). Function of the 2nd and 3rd fingers was restored



FIGURE 2 Defect at the left inguinal region and the penis shaft. A) ipsilateral rectus abdominus muscle flap (shown with star) covered the inguinal region and fasciocutenous flap (shown with arrow) covered the penis shaft B) early postoperative appearance of repaired skin defects C) late postoperative appearance of repaired skin defects D) right mid-forearm amputation stump E) preoperative marking for free thoracodorsal artery perforator flap F) transferred flap to mid-forearm amputation stump G) postoperative appearance of amputation stump



FIGURE 3 Defect at the left mandibular region A) preoperative appearance of mandibular defect B) preoperative radiogram C) harvested osteocutanous fibula flap D) postoperative appearance

with tendon grafts (Figure 4F,G). After initial discharge, the patient was unable to return to our clinic for 2 years. When he returned, the 4th metacarpal and the soft tissue were repaired with a composite osteocutaneous groin flap (with iliac bone; Figure 4H,I). The patient made a full recovery and was discharged without any complications.

3.1.5 | Patient 14

A 51-year-old male patient who suffered blast injury presented in the late period had a defect of 17 × 9 cm in the posteromedial aspect of the distal third of his right arm, exposing the bone (Figure 5A,B), as well as a 10 × 6 cm defect in proximal right arm which was previously repaired with skin graft. Following debridement, repair was performed with a latissimus dorsi pedicle flap containing a skin island of 18 × 8 cm (Figure 5C,D). A seroma that developed in the donor site regressed after being discharged by puncture a few times. He was discharged with a physical therapy protocol in order to increase his range of motion.

4 | DISCUSSION

The border between Turkey and Syria is quite long at 877 km, making Turkey the neighbour that experiences the harshest and most



FIGURE 4 Defect at the dorsal left hand A) preoperative appearance B) preoperative marking for free osteocutaneous fibula flap C) flap inset D) postoperative appearance E) three dimensional tomographic appearance F) tendon transfer G) functional demonstration after tendon transfer H) composite osteocutaneous groin flap appearance I) separated groin flaps appearance



FIGURE 4 Continued

severe effects from the Syrian Civil War. The war started on April 15, 2011, when the Syrian army fired on demonstrations against Bashar al-Assad, and soon spread to the entire country.[3] After the hospitals were destroyed and the health infrastructures were damaged, thousands of war victims were brought to our country and were treated in many different hospitals.[4] As a result of the destruction of Syrian hospitals and damage to the Syrian health infrastructure, thousands of wounded refugees have been brought to Turkey for treatment. While mild injuries have been treated in small hospitals, most patients with severe and complex injuries have been treated in our hospital, which is the best-equipped hospital in the region. All refugees in Turkey are provided with free-of-charge healthcare services at all levels, from first-line preventive healthcare to last-line treatment services. As of 2020, half a million people have died in the war, and 2 million have been injured. According to the official website of the United Nations High Commissioner for Refugees, the number of Syrian refugees in Turkey is 3,586,069 as of March 2020.[5]

In the past, war injuries were mostly sustained on the battlefield and were usually treated by military surgeons. However, as acts of terrorism against civilians have gradually increased in recent years, civilian surgeons are now encountering such injuries too.

Blunt trauma was initially the most common type of war injury; penetrating stab injuries became more prevalent later in history. Today, however, war injuries may be caused by bullets, blasts, burns, cold, or chemical, biological or thermonuclear weapons. Bullets generally cause damage through penetration. Blast injuries may be divided into 3 types: primary, caused by the impact of the blast wave on the body; secondary, which may be penetrating or nonpenetrating and are because of projectiles or shrapnel fragments scattered by the blast; and tertiary, which occur as a result of being thrown by the blast.[6] The present study covers the repair of the defects caused by bullet and blast injuries.

War injuries differ from other injuries in the greater extent of tissue damage and high risk of contamination. Most of the patients included in this study reached the hospital by their own means or were transported by ambulance under inappropriate conditions for hours after injury. Transferring patients from remote areas under inappropriate conditions increases the risk of mortality. Moreover, it increases the infection risk, which is already high, resulting in longer hospitalisation, a higher number of operations, a greater labour requirement and higher costs.

Soldiers and civilians receive different types of injuries. While penetrating injuries are higher in number and more fatal in soldiers, civilians mostly sustain blunt traumas, with remarkably long periods of hospitalisation.[7] In our patients, most of whom had blunt traumas, long periods of hospitalisation were frequent. This is because such

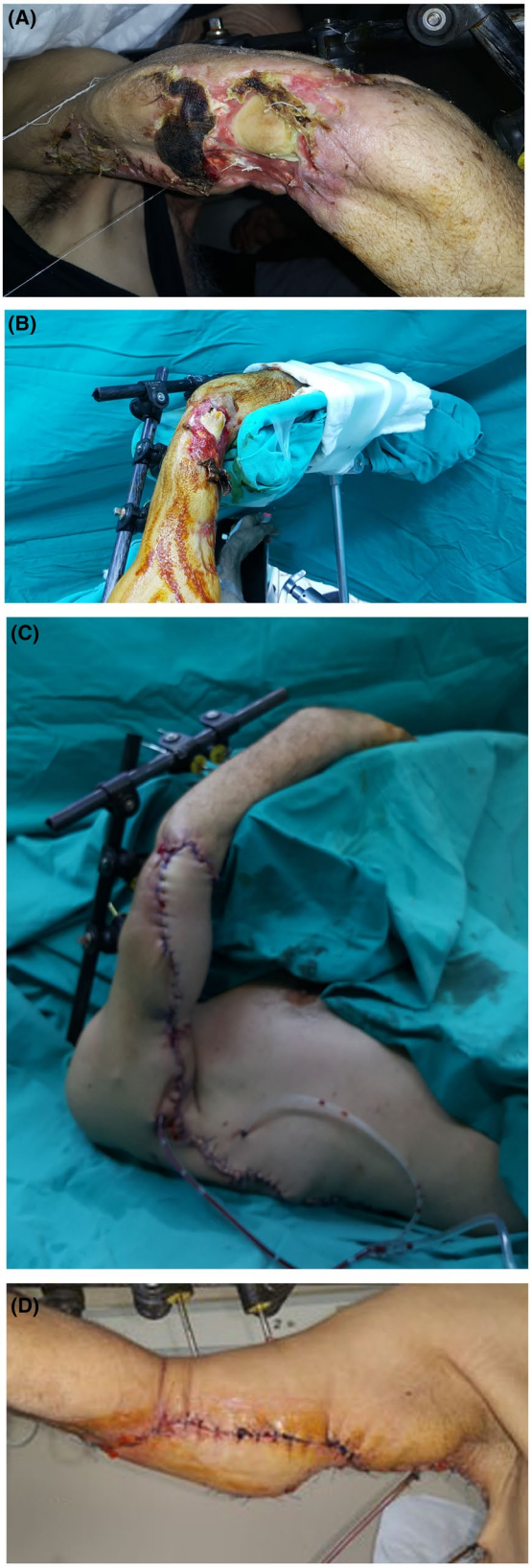


FIGURE 5 Distal right arm defect A) right arm defect with exposed bone B) preoperative appearance C) transferred latissimus dorsi myocutaneous flap D) postoperative appearance

injuries involve more tissue damage, pose a greater risk of infection and require a high number of debridement before the major surgery.

Seventy percent of war injuries affect the musculoskeletal system.[8] The trunk and head/neck areas are less commonly affected. Therefore, a multidisciplinary approach involving general surgery, cardiovascular surgery, otorhinolaryngology and orthopaedics in addition to plastic surgery is of great importance. Extremity injuries have a low mortality rate, while cranial, trunk and thoracic injuries have a high mortality rate.[9] In the present study, the majority of patients had extremity or head/neck injuries (Table 1).

4.1 | Extremity repair

Early debridement of avascular tissues is very important in extremity crush injuries. Debridement of foreign bodies and necrotic tissues reduces tissue hypoxia and risk of infection.[10] Depending on the type and severity of the injury, a single debridement may not be enough, in this case, debridement can be repeated after 48-72 hours.[11]

To prevent loss of extremities, we applied a variety of repair methods to our 30 patients with extremity injuries, including debridement, negative pressure wound therapy, skin grafts, and pedicle or free flaps. Eleven of the injuries involved the upper extremities, while 19 involved lower extremities. Repairs were performed following preparatory wound care in three patients with upper extremity defects, seven who received pedicle flaps and three who received skin grafts. There were two cases of metacarpal defect; one was repaired with a free fibula flap, the other with free fibula and composite groin flaps. Free fibula flaps were first used for extremities and the mandible in 1975 by Taylor et al[12] Using free fibula flaps on composite metacarpal defects has certain advantages: the fibula and the metacarpal bone are compatible in terms of size, osteotomy is possible because of segmental blood supply, the skin on the fibula is thin, morbidity of the donor site is low and the flap can be used as a flow-through flap to facilitate finger revascularisation.[13-17] In addition, better function can be obtained by using tendon grafts and tendon transfers.[18] The free fibula flap is quite a good option for the repair of shoulder and wrist joints or segmental defects of the long bones in the upper extremities.[19]

The groin flap, which is preferably used with a pedicle, is a reliable choice for repairs of soft tissue.[20] It can also be prepared as a composite flap with the iliac bone, as we did for one patient.[21] For digital defects, the composite groin flap can provide elongation of the bones as well as covering the soft tissue.[22]

We also used the free fibula flap in patients with bone defects in the lower extremity (tibia and femur). If the vascular structures allow, tibial bone defects can be repaired with a fibula pedicle flap, or if not, with a free fibula flap from the other leg. If an ipsilateral

flap can be used, the operation time will be shorter, there will be no anastomosis-related risks and the other leg will remain intact.[23-25]

We used ALT flaps for three patients with soft tissue defects of the lower extremities; for two patients with larger defects, we used free latissimus dorsi flaps. Muscle flaps have been shown by experimental studies to increase blood flow, oxygen concentration and phagocytic activity at the injury site, as well as decreasing bacterial load; they have been used for lower extremity repairs for many years.[26,27] They also accelerate bone recovery in the early phases of repair.[28] Although there are studies demonstrating that muscle flaps have better blood flow, fasciocutaneous flaps have also been used successfully for this purpose.[29,30] The ALT flap has become quite popular in recent years, as it has acceptable donor site morbidity, appropriate vessel diameter and a long vascular pedicle; in addition, it can be used in large defects, and flap thickness is adjustable.[31-33] Furthermore, it can be prepared as a flow-through flap to ensure that blood flow can be sustained through the vascular gaps in the extremity.[31,34,35]

The pedicle flaps that are used the most for lower extremity defects are the gastrocnemius and soleus muscle flaps and the sural flap. Although they have been increasingly replaced in recent years because of the introduction of perforator flaps and wider experience with free flaps, the conventional gastrocnemius and soleus flaps maintain their importance in the repair of defects of the upper and middle thirds of the leg, respectively.[36-38] We also prefer the muscle pedicle flap, as it is simple and reliable for patients with defects involving a deep pouch in the leg. Conventional pedicle flaps and sural fasciocutaneous flap are the most widely used reconstruction methods in the literature for war-related injuries to the lower extremities.[39]

4.2 | Head/neck repair

Head and neck injuries are important as they are life-threatening injuries.

At the start of treatment, the airway should be cleared, and first aid procedures such as bleeding control and respiration and circulation checks should be immediately performed; this is particularly important for patients with face injuries.[40] Subsequently, repair should be performed immediately in the case of an emergency, or in the following days if the situation is not urgent. For example, in the case of facial bone fractures, fixation can be begun immediately if the conditions are appropriate. However, if the patient is not in a good general condition, and if generalised oedema and hematoma are present, reconstruction and fixation may be delayed in the absence of appropriate technical conditions. To ensure successful repair, it is essential to administer a series of debridement procedures, wound irrigation and dressing, and proper antibiotic therapy before the actual repair stage. We repaired facial bone fractures using rigid fixation (titanium micro-/mini-plates), local flaps, and, if necessary, bone grafts. Free osteocutaneous fibula flaps were used for two patients with mandibular defects and one with a maxillary defect.

The iliac bone flap, which is hard to dissect, has a short vascular pedicle, and may cause development of abdominal hernia in the donor site, was once standard for mandibular repairs; in 1989, Hidalgo introduced the use of the free fibula flap for mandibular repairs.[41] Over the years, sensate osteoseptocutaneous fibula flap has been introduced, and the free fibula flap has today become the gold standard in mandibular repair.[42] In recent years, thanks to advances in technology. better results have been obtained in mandibular repairs through computer-assisted mandibular modelling.[43]

Options for the repair of firearm-caused soft tissue defects of the neck region include free flaps (ALT, radial forearm, rectus abdominis, latissimus dorsi), muscle pedicle flaps (trapezius and pectoralis major myocutaneous flaps) and fasciocutaneous perforator flaps. Today, free flaps are the first treatment choice in head/neck repairs because of their aesthetic appearance and great functional advantages. However, pedicle flaps may be preferred where using free flaps is not feasible.[44] In cases where the head/neck defect needed to be urgently repaired because of the poor general condition of the patient, or in the absence of a recipient vessel for a free flap, we preferred the pectoral muscle flap, the deltopectoral flap, and the transverse cervical artery perforator flap. The advantages of these flaps are that they can be swiftly prepared, ensure good blood flow and are compatible in colour with the head and neck region.

4.3 | Trunk repair

A majority of the injuries we encountered in the trunk region involved the inguinal area. Repair options for defects of the inguinal area include muscle flaps (sartorius, rectus femoris, rectus abdominis, tensor fascia lata or gracilis),[45-47] and perforator flaps (ALT, posteromedial thigh, deep inferior epigastric artery perforator).[48] Some of these flaps have certain disadvantages: the sartorius flap has a limited rotation arc and remains insufficient in large defects; the rectus femoris flap may cause a decrease in the extension strength of the thigh; and the gracilis flap may cause necrosis of the skin island. We treated three patients with a rectus abdominis muscle flap, two with an ALT flap, one with a graft and one with suturation. One patient whose defect was repaired with a rectus abdominis flap had an injury to his femoral artery and vein; he had undergone a repair procedure with a synthetic vascular graft in the cardiovascular surgery unit of another hospital. Infection-related complication risk is higher in patients who have undergone repair with synthetic vascular grafts.[45] In patients with a large inguinal defect who have a risk of infection, we usually prefer two flaps with good blood flow, such as the rectus abdominis and ALT flap. Previous studies have compared the two types of flap in terms of major postoperative complications (eg injury site complications, pelvic abscess and abdominal hernia) and obtained different results.[49,50] We encountered complications of hematoma and suture detachment in this area; however, the number of patients with injuries in this area was low. Defect repair in the inguinal area is not easy, as the femoral artery/vein and nerves are located in the area. In our series, repairs were performed on five patients using

major flaps such as the rectus muscle flap and the ALT flap. It took a long time for the patients to achieve full recovery and be discharged (mean time 47.5 days).

4.4 | Additional considerations

Generally, debridement of devitalised tissues is critical for the success of any attempt at injury reconstruction.[51] With high-energy blast injuries, performing debridement and irrigation more than once is necessary. One of the conclusions we have drawn from our experience with these injuries is that there is a high risk of infection and osteomyelitis even if debridement has been performed. Although the above-mentioned factors account for the long hospitalisation periods of our patients, another reason is that they were not discharged until they had achieved full recovery, as many of them were to return to a refugee camp or their own country and thus would have difficulty in returning to our hospital.

The first choice for repair following debridement was suturation/skin grafts. In this study, the number of patients who were treated using skin grafts or suturation was lower than expected. The reason for this is probably that such repairs could be conveniently performed in the surrounding hospitals, and only more complex cases were referred to our hospital. If the defect was not eligible for a simple repair, regional flaps (musculoskeletal or fasciocutaneous) became the first choice, followed by free flaps, depending on the reconstruction step. What flap to be used for the repair of a defect should be determined according to the location of the defect, the condition of the vessels in the area, the infection status of the area, and the surgeon's experience. Furthermore, the size of the defect, presence or absence of a bone defect in addition to the soft tissue defect, and flap pedicle length should be taken into consideration to ensure easy positioning during the operation.[52] Another point to consider in defect repairs is the timing of the repair. Free flap losses mostly occur in the subacute phase, 72 hours to 3 months after injury.[11] Repairs conducted in the first 72 hours after injury have a higher chance of success. We did our best to adhere to this schedule during the repair procedures we carried out.

5 | CONCLUSION

Efforts to treat war injuries have made great contributions to the advancement of surgery, especially the reconstruction phase of plastic surgery. We treated the head/neck, extremity, and trunk injuries of refugee patients with a wide variety of repair methods. The conclusions we have drawn from this study are the following:

First, war injuries affect civilians as well as soldiers. Second, the most common war injuries are extremity injuries; however, head/neck and trunk injuries may also occur. As these injuries involve composite damage and extensive areas of tissue, their treatment can be complex and requires a multidisciplinary approach. In addition, these injuries are associated with increased infection rates and prolonged hospitalisation periods, increasing treatment costs. Third, the fact that most of our patients were young likely improved the chance of treatment success. Fourth, when performing repairs on young patients, covering the defects should not be the sole aim; the anatomic, functional and aesthetic effects of the repair should also be taken into consideration. Fifth, when treating refugee patients, the methods to be preferred are those that are the most practical and the fastest and those that minimise the requirement for follow-up, so that patients can go back to their normal life faster; furthermore, the patients should be hospitalised until full recovery.

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CONFLICTS OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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