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Original Research

Viability and Functional Prognosis in Mangled Hand Casualties Depending on Their Etiological Factors. A Study of 31 Cases

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Purpose: Mangled hands refer to disfiguring severe injuries that affect many anatomical components. These injuries are evaluated using various scoring systems. In addition to these ratings, we need to include critical aspects relating to the patient, such as the trauma origin, prognosis, and procedure. We examined the significance of accident etiology in assessing trauma and predicting outcomes, as well as their value in guiding decisions for trauma treatment.
Methods: Thirty-one patients, from 6 to 73 years, have been treated for upper limb compound injuries at our hospital between 2004 and 2009. We registered 10 blast injuries, 10 work accidents, six motor vehicle accidents, and five gunshot injuries. The severity, anatomy, topography, and type assessment method was used to evaluate the prognosis on viability and functionality. Additionally, we studied the influence of the etiological factor on injury prognosis. The functional results have been assessed by the manual muscle testing grading system, whereas the results of the limb usefulness have been evaluated by Disabilities of Arm, Shoulder and Hand (DASH) score test (patients' self-questionnaire).
Results: Seventeen cases involved major vascular lesions that required emergency reconstruction or amputation. Our findings indicate that cases with blast injuries managed by partial or total amputations or using flaps to close stumps had poor prognoses. For cases with work-related injuries, we performed revascularization or flaps where the likelihood of saving the limbs was deemed higher than the potential risks of postoperative complications. In cases with gunshot injuries, despite the low overall functioning seen, our primary approach was to repair rather than amputating because of the potential feasibility of achieving viability.
Conclusions: Further investigation is needed to determine if the cause of trauma has an important impact on trauma evaluation scores and predicting trauma outcomes, furthermore, helping decision making in emergencies.
Type of study/level of evidence: Prognosis IIa.

Mangled hands are intricate injuries that affect several structures (muscles, bones, skin, and neurovascular components), produced by pressures that lead to tearing, crushing, or cutting.[1–3] Mangled hands are injuries that result in a limb being almost unidentifiable. Traditionally, mangled limbs led to amputation. Progress in microsurgery and evaluation methods enables better prognosis and outcomes.[1–4]

The decision of whether to preserve the limb or proceed with amputation depends on systemic and local circumstances. The priority is the management of internal organs, since the integrity of them may considerably impact decision making and prognosis.[1] Following the treatment of internal organs and preserving life, the restoration of limbs should commence as soon as possible. Tissue defects must be covered by composite flaps, although the choice to do one single complex surgery or operate in steps relies on the surgeons' expertise.[3] The successful prognosis of proper therapy for mangle hands depends on their assessment score grade. Different assessment methods are used to score injuries, depending on the reference center.[4–6] The evaluation process starts by

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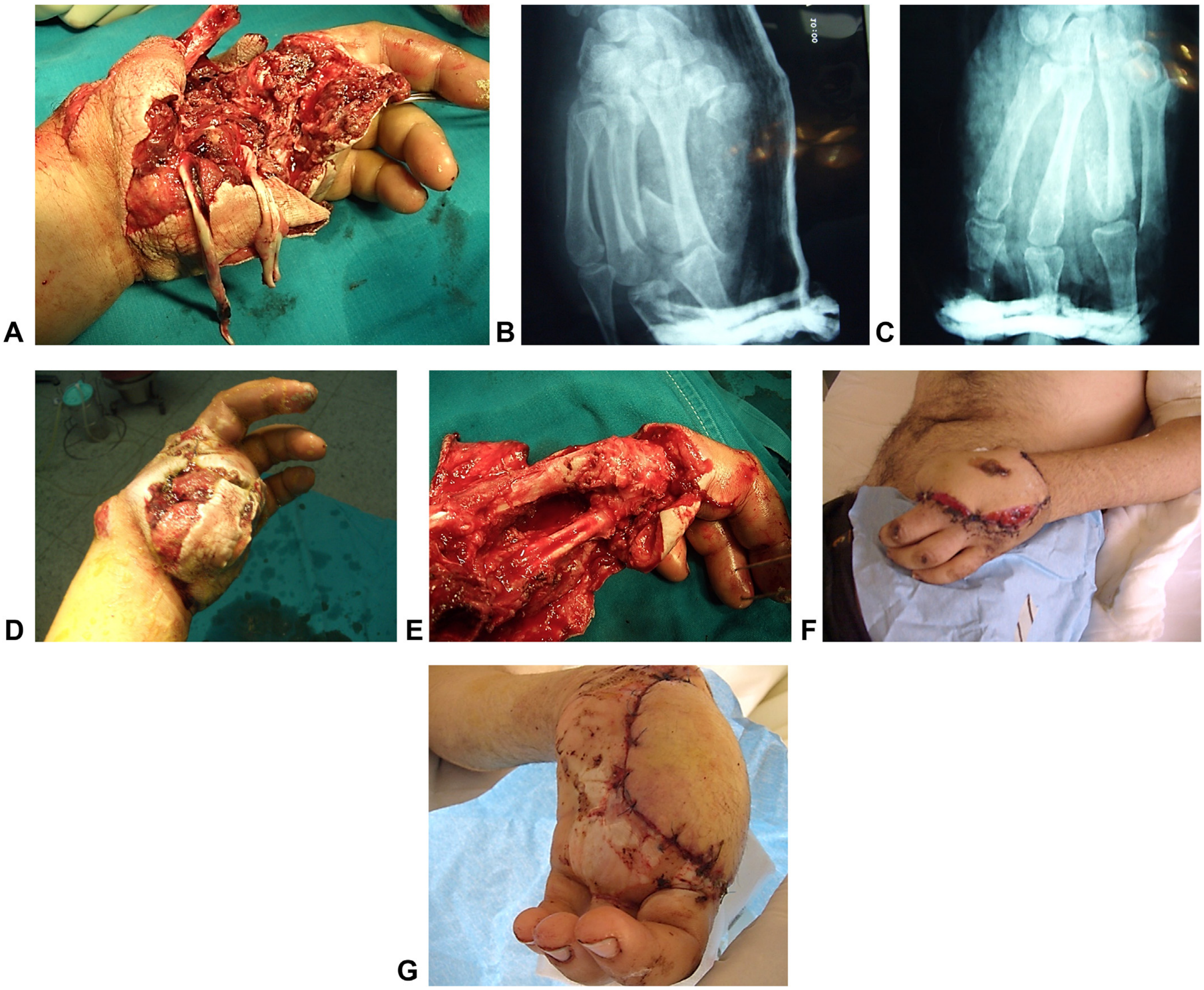

Figure 1. Seventeen years male-blast injury of the left hand with thumb and index finger amputation; **A** preoperative aspect (emergencies); **B**, **C** X-ray aspects; **D** aspect before second surgery (flap); **E** after debridement; **F** the defect covered with a groin flap; and **G** poor final result.

identifying any life-threatening injuries, followed by identification of the affected structures.[1,7] We must save as much as possible and minimize the "warm ischemia time." After performing meticulous debridement, a reconstructive approach must start to maximize the chances of restoring the functionality.

The Mangled Extremity Severity Score (MESS) was developed to determine whether amputation should be performed in limb injuries.[6,8] Mangled Extremity Severity Score evaluates the following four factors related to injuries: the severity, the "warm ischemia," the shock, and the patient's age. A score above 7 indicates the need for initial amputation. Nowadays, MESS is not a reliable predictor of the need for amputation.

Current methods lack reliability in predicting the efficacy of salvage procedures or the outcomes of severe injuries. A recent method, called Mangled Upper Extremity Score, demonstrates substantial correlations with outcome variables such as the problems experienced during hospitalization and the duration of hospital stay.[8,9] A systematic review was published using the Preferred Reporting Items Systematic Reviews and Meta-Analysis standards. The review procedure was registered in Prospective Register of Systematic Reviews.[10] The search strategy was performed on MEDLINE, EMBASE, and Cochrane databases and was evaluated using the Risk Of Bias In Non-randomised Studies of Interventions tool. The criterion for amputation examines at least two of the following conditions: hemodynamic instability, defects, ischemia, vascular trauma, and crush damage.[8,10]

An alternative system that evaluates patient-reported functional and psychological outcomes following amputation, versus limb salvage, is the Mangled Extremity Syndrome Index, which is an accurate tool for choosing between amputation and reconstruction.[10]

Patient's age is another factor that influences the outcome of these injuries. Childhood promotes the restoration choice of severe traumas, even in moderately mangled limbs.[11] Another prognostic element that should be investigated is the accident's etiological factors. Prognosis and care of mangle hand injuries varies depending on the etiological factor and should be customized to the underlying cause.

Materials and Methods

From 2004 to 2009, the authors' facility admitted 31 patients, ranging in age from 6 to 73 years 24 males and 7 females, who

Figure 2. Labor accident, male 43 years, open fracture III Gustillo; **A** clinical and **B** radiological trauma aspects; **C**, **D** exfix and skin closing; **E** radiological aspect-exfix and antibiotic granules; **F**, **G** ORIF radiological aspect; **H** 1-year radiological result; and **I1**–**I4** 1-year fair functional results. Exfix, external fixation; ORIF, open reduction internal fixation.

experienced severe deforming complex upper limb injuries affe-discting at least three kinds of tissues (between bone, nerve, vessels, muscle, or tendons) plus the skin, causing a significant deformation or distortion of the limb aspect in its diverse levels (elbow, forearm, wrist, and palm). These injuries include muscle lesions with wide loss of mass or vascular injuries, both of which put at risk the limb viability. We excluded clear cut injuries, such as amputations, from the study. To collect a reliable number of cases for filling with all etiological factors groups, we included them in casualties from both macrosegment (arm, forearm, and wrist) and microsegment (hand, palm, and fingers) groups.

The study seems to be valid because in all etiological groups, we equivalently included both macrosegment as well microsegment injury groups.

The above-mentioned cases were caused by the following factors: 10 blast injuries (Fig. 1), 10 work accidents (Figs. 2–4), six motor vehicle accidents (Fig. 5), and five hunting gunshot injuries (Fig. 6). All patients gave written informed consent for their data to

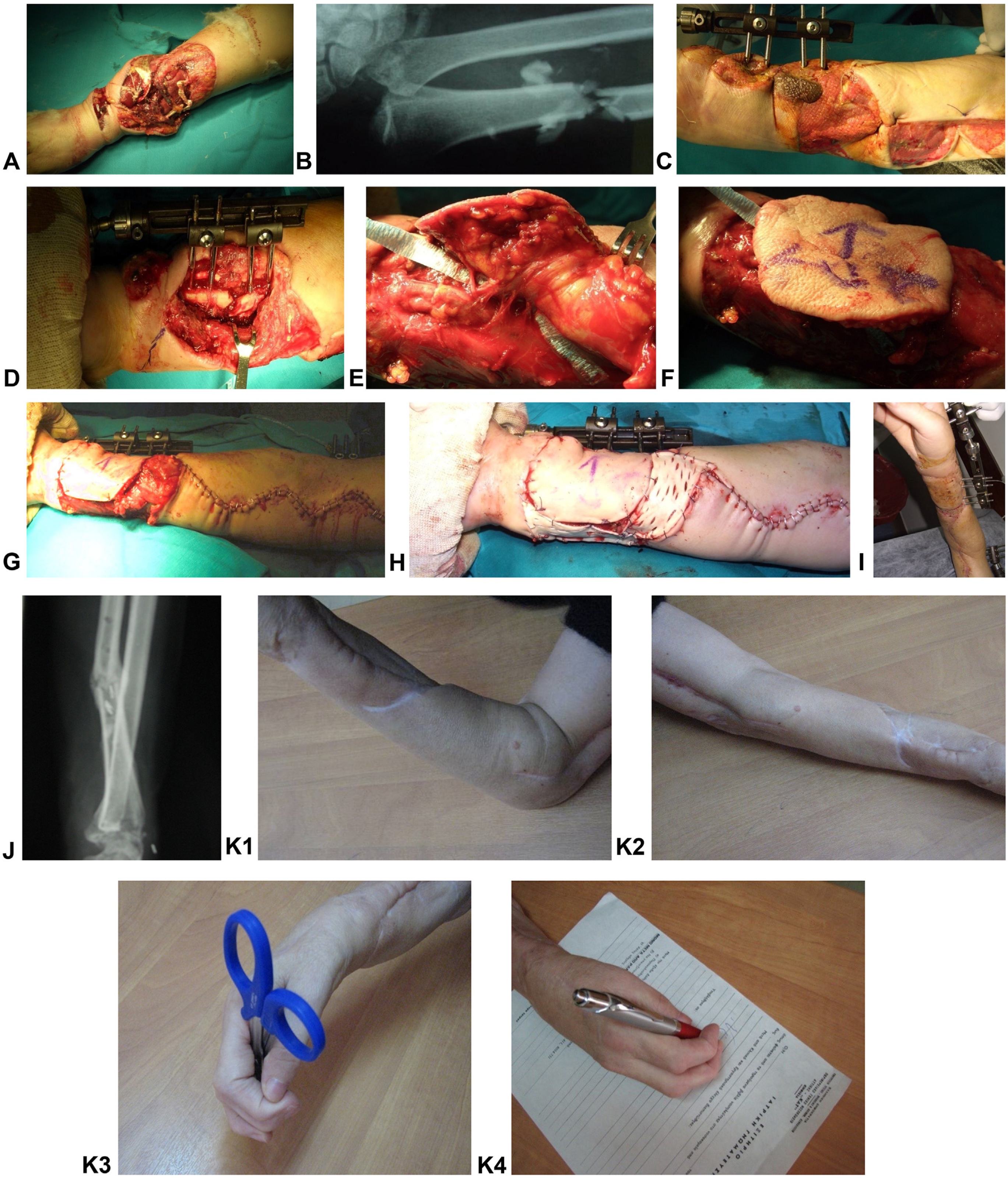

Figure 3. Labor accident, female 53 years, open fracture III Gustillo; **A**, **B** clinical + radiological aspect of the fracture. **C** After exfix application **D** defect after debridement; **E**–**H** transpositional perforator radial flap, dissection, harvesting, defect coverage, final aspect; **I** 3 months flap healing; **J** exfix removal, radiological healing; and **K1**–**K4** 6 month fair elbow and hand results.

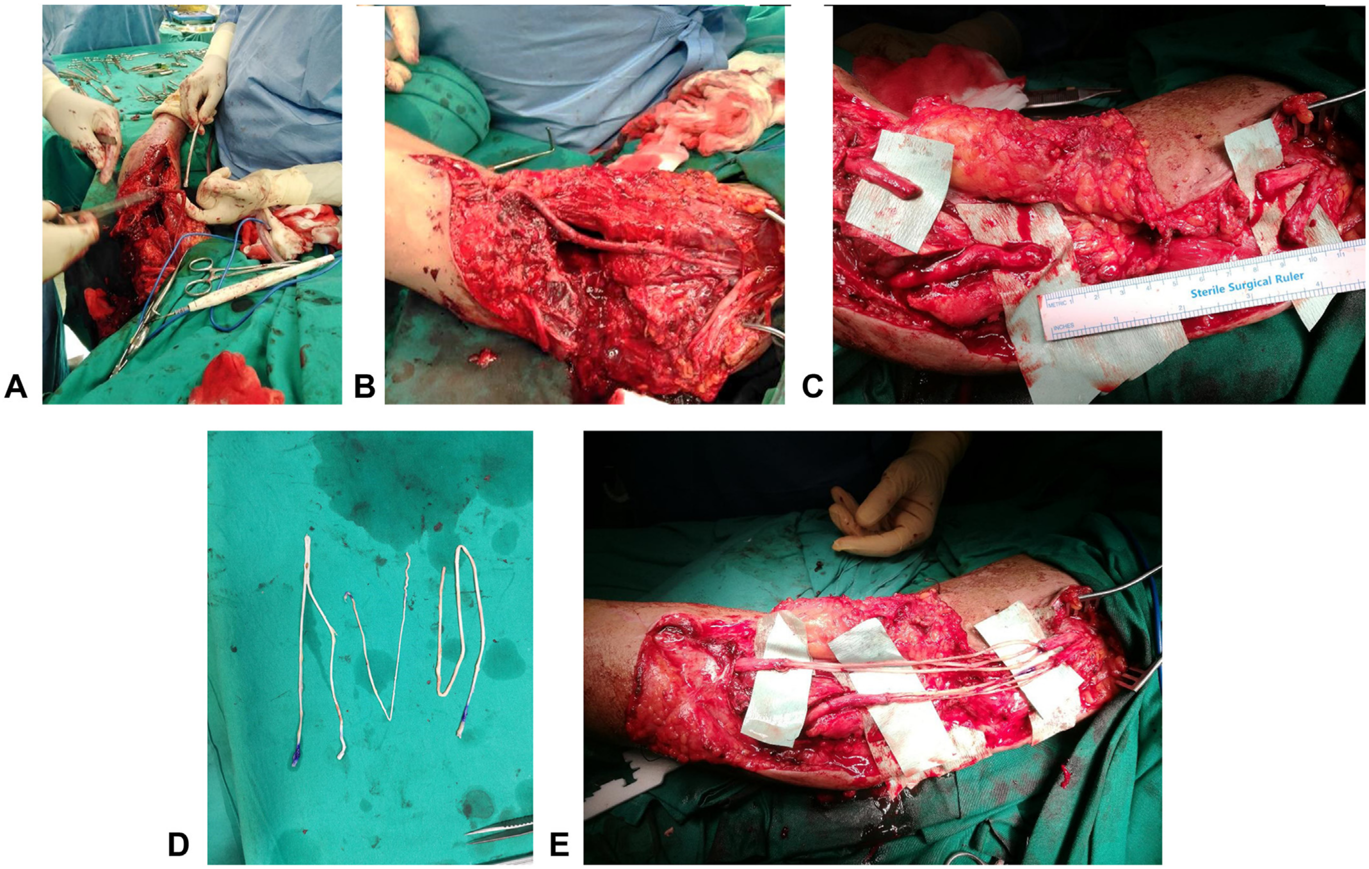

Figure 4. Arm compound injury. High pressure water injection labor accident, male 29 years; **A**, **B** surgery in emergency: bridging brachial artery 18 cm defect by saphenous vein and marking lacerated nerve stumps; **C** median and ulnar nerve defects dissection; **D** sural nerve harvesting; and **E** grafting by sural nerve both median nerve (15 cm defect) and ulnar nerve (10 cm defect); **F1**–**F6** 1-year fair result (after tendon transfers plus Zancolli-Lasso tenodesis).

be included in this study. This study was approved by the Ethics Committee of the authors' Institutions.

The blast injuries have been inflicted by explosive devices. All injuries were initially assessed and described using the severity, anatomy, topography, and type (SATTy) assessment scoring system, which is associated with predicting the prognosis of the injury (Table 1).[12] All patients (Table 2) had complex injuries of the upper limb that affected diverse tissues (type A2). Seventeen individuals underwent either partial or complete amputations of nonviable (S2) forearms (12) and fingers (5). Of the injuries involving amputation, microsurgical repair was attempted in nine cases. This included three cases of direct arterial anastomoses (one brachial artery and two digital arteries) and six cases (involving brachial arteries) treated with vein grafts. In the other 10 cases, a primary amputation and stump closure have been performed.

We have performed all neurovascular sutures under a microscope, using microsurgical tools and sutures. After vascular anastomoses, we administered dextran and antiplatelets intravenously. Fourteen patients had crush injuries of S1Ty2 type, resulting in damage to at least two separate types of tissues.

Primary end-to-end tendon and nerve repair have been conducted in patients with nerve or tendon defects. Nerve grafting was performed in three instances, whereas vascularized flaps were used for 17 patients (nine in emergency and eight later). Fourteen pedicle fasciocutaneous flaps, two free transfers (one free Chines and one free Gracilis), two groin flaps, and one muscle (Latissimus) reversed pedicle flap have been performed, providing tissues with blood, oxygen, and antibiotics. Three patients with fasciocutaneous perforator flap partial necrosis had a sequential treatment including three new flaps: ulnar perforator flap, which experienced a partial necrosis, was followed by radial perforator flap; radial flap, which experienced a marginal necrosis, was repaired later by an adipofascial ulnar flap; and a radial flap with a small necrosis was followed later by groin flap. More analytically among the 14 fasciocutaneous pedicle flaps, five were ulnar flaps (two in emergency), eight were radial flaps (five in emergency), and one was a dorsal interosseous flap (in emergency). Additionally, there were two groin flaps (performed later) and one muscle motorizing transfer (Latissimus transfer to biceps). We also have performed a free Gracilis transfer and a contralateral transfer of a forearm through a flow flap.

Two of the individuals with elbow motor vehicle accident (MVA) were first treated with brachial artery grafting and subsequently underwent reconstruction using an elbow prosthesis.

Eleven patients required secondary tendon transfers. Four secondary operations were conducted in two phases, first as wrist or thumb arthrodesis and after tendon transfers. We conducted in one case tenolysis, and in three instances, nerve grafting.

Hyperbaric oxygen therapy was used in three instances, specifically for wound healing, followed by negative pressure therapy using the vacuum assisted closure equipment.[10,13] Sensory recovery was assessed using the static and moving two-point discrimination test, as well as the tactile gnosis as per the modified Moberg pick-up test.[10,14] The grading of sensory recovery was evaluated by categorizing the results of the two-point discrimination test using the scoring system S1-S3. Normal sensation was defined as static less

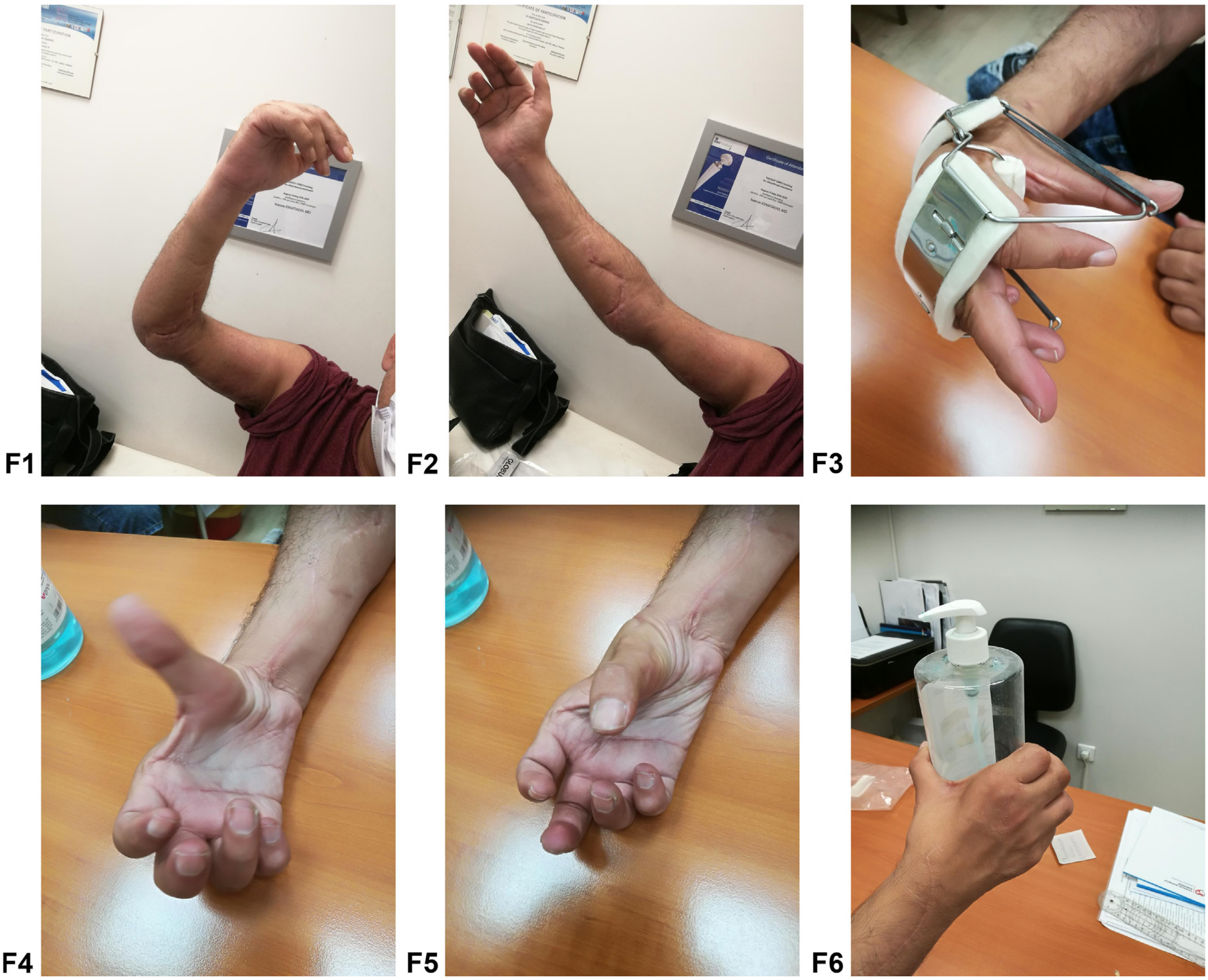

Figure 4. (*continued*).

than 6 mm and moving 2–3 mm; good sensation was defined as static 6–10 mm and moving 4–6 mm. Poor sensation was defined as static 11–15 mm and moving 7–9 mm. The assessment of motor recovery evaluated the strength and functionality of the reinnervated muscles, using principles of gravity and resistance. The dynamometer JAMAR was used to assess grip and pinch strength, measured in kilograms following the manual muscle testing grading system and assigns a numerical value ranging from 0 (weakest) to 5 (strongest), denoted, respectively, as M1-M5 (Table 3).

We conducted a descriptive analysis to determine the proportion of injuries for each type. Following the SATTy assessment of the damage and the manual muscle testing grading system and DASH score evaluation of the functional outcomes, we conducted a percentage descriptive analysis for each etiological group. The postoperative follow-up period was between 1 and 4 years. DASH score for the hand-arm-shoulder derives from a 30-item self-report questionnaire that looks at the ability of a patient to perform certain upper-extremity activities.[15,16] The patients can rate difficulty and interference with daily life on a five-point Likert scale (1 = no difficulty, 2 = mild difficulty, 3 = moderate difficulty, 4 = severe difficulty, and 5 = unable).[15,16]

Results

Based on the causes of the injury, we identified the following: 10 blast injuries (Fig. 1), 10 work accidents (Figs. 2–4), six MVA (Fig. 5), and five hunting accidents (Fig. 6). Of our instances, 17 were classified as nonviable (S2); among them, there were six cases of limb amputation, two cases of incomplete limb amputation, four cases of partial limb amputation, and five cases of finger/thumb amputation.

Nine instances underwent revascularization attempts, resulting in successful outcomes in five cases involving limbs and one involving fingers. Two revascularizations performed in the forearm have failed, and one failed in the palm.

Of the 12 crush-type injuries (S1Ty2) that were treated, three were performed as emergency procedures. Twenty patients were treated with direct suturing of tendons and nerves, where a moderate improvement in function, as assessed by the Dellon-McKinnon score, was found. The mean recuperation of sensory perception and postoperative motion was 50% compared with the unaffected limb. Three instances involving nerve grafting exhibited diminished feeling compared with the unaffected side.

Figure 5. MVA accident, male 45, nonviable, open fractures of humerus transcondylar and of olecranon with bone defects. **A** Trauma clinical aspect; **B** radiological aspect of exfix stabilization; **C**, **D** brachial artery tear bridging by vein and median nerve suture; **E** 6-month clinical + aspect; **F** after exfix removal radiological aspect; **G** elbow arthroplasty; **H** first metacarpal rotational osteotomy plus thumb opposition transfer (median nerve substitution); and **I1**–**I3** 8-month fair result. Exfix, external fixation.

Of the 31 instances in our research, 15 limbs or fingers have undergone amputation, resulting in a proportion of 48.38%. Two replanted individuals exhibited postoperative stiffness and atrophy. Totally, 17 instances had a nil/poor outcome (nil 6 and poor 11), representing 54.83% of the sample, demonstrating that mangled hands have an unfavorable impact on the survival chances and functional recovery.

Ten of 14 nonamputated patients had an average sensory and motor capacity score ranging from S1M2 to S2M3, whereas four patients were categorized as S3M4.

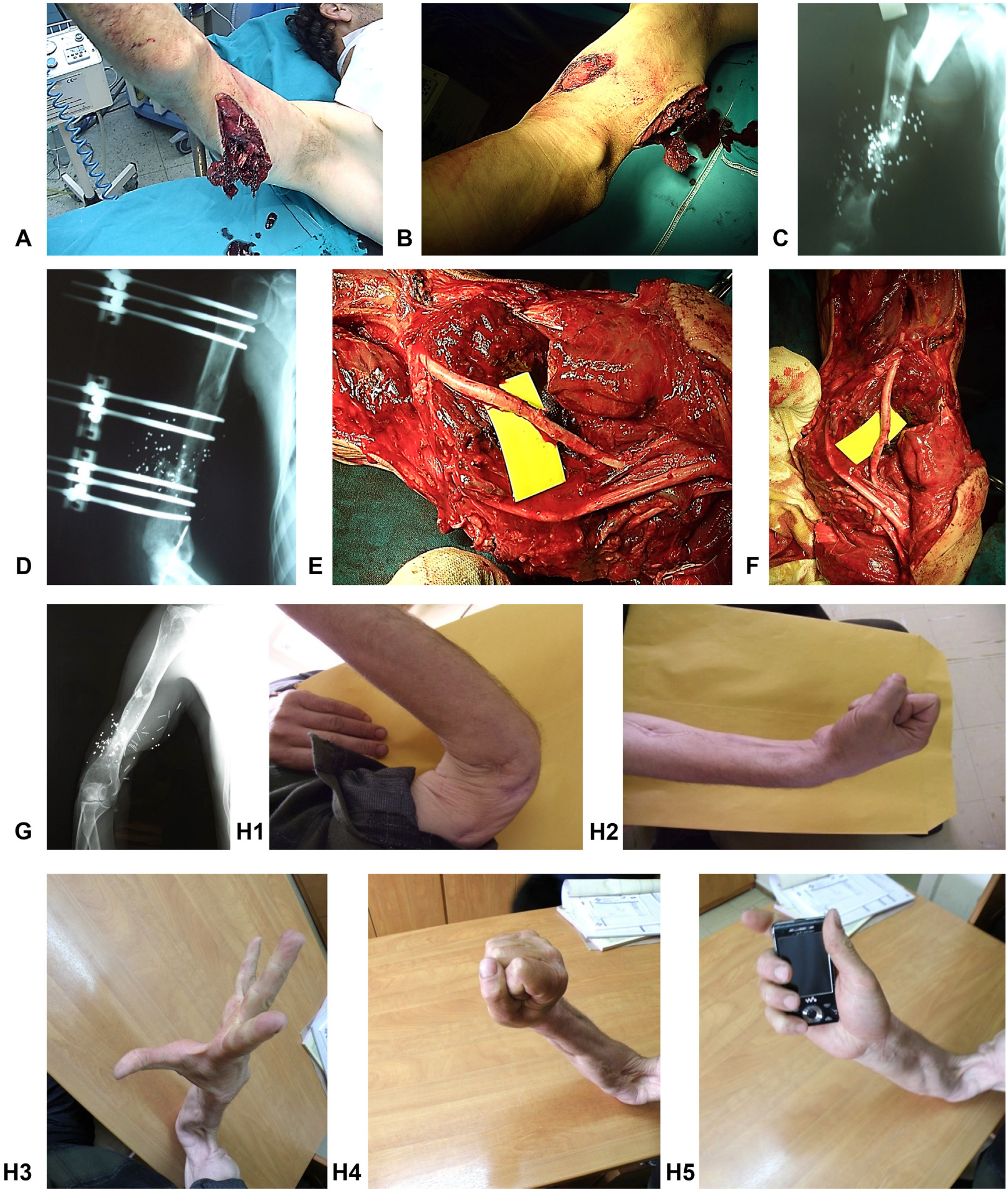

Figure 6. Hunting gunshot injury, male 46 open fracture, nonviable. **A**, **B** First trauma aspects; **C** radiological aspect of the fracture; **D** exfix application-radiological aspect; **E**, **F** brachial artery vein bridging; **G** 5 months, exfix removal radiological healing; and **H1**–**H5** 7-month fair elbow-hand functional result. Exfix, external fixation.

Table 1
The Severity, Anatomy, Topography, Type Trauma Evaluation System

SATTy Trauma Evaluation System		
Examined Factor (Parameter)	Grade 1	Grade 2, 3
Severity	S1-Viable	S2-Nonviable Severe vascular damage
Anatomy	A1-Isolated-one anatomical structure	A2-Extended – compound injury
Topography	T1-Palmar	T2-Dorsal T3-Amputation
Type	Ty1-Clear cut injury	Ty2-Crush injury – avulsion

Based on both the etiology and prognosis of viability and functionality, we have analyzed the data and provided the following: of the 10 blast injuries, we conducted amputations or failed salvages in eight limbs. We achieved nil or poor results in eight patients, resulting in an 80% amputation rate and an 80% rate of nil/poor outcomes. Of the 10 upper limb injuries resulting from work accidents, four cases had amputation (40%) and four cases had fair outcomes (40%). Of the six upper limb injuries resulting from MVA, there were two amputations (33.3%) and three of six cases with poor outcomes (50%). Of the five gunshot injuries, there was only one amputation (20%), whereas three cases had poor outcomes (60%).

Advanced methodologies enhance results in even intricate injuries, but functional restoration is not certain. No scoring method can definitively determine the threshold for choosing amputation over salvage. Amputation should not be necessarily considered a therapeutic failure but rather as a method of achieving treatment objectives in some cases.[7] DASH score test for the upper limb functionality showed: five cases grading with 5 (unable), 10 cases grading with 4 (severe difficulty), and 16 cases grading with 3 (moderate difficulty). We remark that from the 7 females included in our sample of 31 patients, 3 had suffered MVA accident and 4 labor accident, while from the 24 male patients 10 suffered blast injuries, 5 gunshot injuries, 6 work accidents and 3 MVA accidents.

Discussion

The prognosis for functional recovery in our patients is worse for mangled hands, with only a 54.83% success rate, whereas the viability rate is 51.62%. A correlation was seen between the treatment result and the damage assessment based on the SATTy system (Table 1). Poor outcomes were seen in instances with full crush injuries at the S2-Ty2 level (S2-A2-T3-Ty2), although cases categorized as S2Ty1 or S1Ty2 gave moderate or severe difficulty results. In relation to the causative elements affecting limb viability and functional outcome, we have determined that blast injuries had the highest rate of amputations, accounting for 80% of cases. Second are labor accidents, with a 40% amputation rate. Motor vehicle accidents follow with a 33.3% amputation rate, and gunshot injuries have the lowest rate of amputations at 20%.

The injuries with worse functional outcomes were blast injuries (most of them assessed as S1Ty2), accounting as nil-poor (5) in 80% of cases (ratio 8:10). These were followed by gunshot injuries, which resulted in poor functional outcomes in 60% of cases (ratio 3:5). Motor vehicle accidents were the next leading cause, with a functional outcome categorized as poor in 50% of cases (ratio 3:6). Finally, labor accidents resulted in poor functional outcomes in 30% of cases (ratio 3:10). The MESS is a tool that uses factors such as the severity of tissue damage, limb ischemia, shock, and age to accurately predict the likelihood of requiring amputation after injury.[12] The diagnostic accuracy of "MESS" in predicting the need for amputation has been diminished by advancements in microsurgery and orthopedics. There is a need to investigate more factors that might predict amputation after serious injuries to the extremities. A hand crush injury with a "MESS" score of 10 or more is associated with a bleak prognosis for successful salvage and functional recovery.[17]

Research found that the Mangled Extremity Syndrome Index scoring system is more trustworthy than the MESS score.[10] However, further validation via a large prospective study is necessary. The primary objective should be salvage, which is determined by several circumstances. The cost of upper limb prostheses is high, and they are not well-tolerated. However, prior research found that patients were accepting of a wooden limb as an alternative.[18]

An ideal approach for managing a mangled upper extremity would be a single-stage restoration or alternatively to restore emergency blood flow to the limb and do the most comprehensive repair possible.[19]

Reconstruction is prioritized above amputation and prosthetics.[19] Due to the distinction in architecture between upper limb and lower limb mutilating injuries, they cannot be considered equivalent.[18] The upper limb has superior vascularization and smaller muscles, resisting a longer duration of ischemia. Distinct grading methods are required for each one of them. Given the concerns about the validity of the MESS scoring system, we have used the SATTy score (Table 1) to provide a better assessment of the kind and degree of damage, offering a more accurate estimation of the prognosis.[12]

The worst prognosis for viability and functionality for mangled hands is associated with blast injuries induced by explosions, 80% of them assessed as S1Ty2. Labor accidents are the second most detrimental prognosis for viability, whereas MVAs rank third. Hunting gunshot injuries have been rated as the least viable prognosis, whereas they rank second in terms of poor functional prognosis. The group of blast injuries, with the highest rate of amputation, exhibited the poorest outcomes as well. This correlation between amputation rate and functional result was observed across all types of causes, except for the group of gunshot injuries. Despite having a relatively low amputation rate (20%), this group also displayed a high percentage (60%) of poor functional outcomes. Fasciocutaneous perforator flaps are an important resource for surgeons when dealing with type S1Ty2 cases, which include healthy tissue but with crush or avulsion injuries. We also can commend that in our sample of 31 emergencies, female patients had not suffered blast and gunshot injuries, probably because they have not been involved in such kind of activities, while females have been involved equally with males in the group of the MVA accidents. Concerning the labor accidents, we observe that males have been more affected that female patients.

Based on our analysis and relevant literature, we conclude that the effective treatment of severely injured hands requires early intervention, a multidisciplinary approach, and a series of planned treatments.[18] Physiotherapy has a crucial part in restoring function. Early and thorough damage control, precise evaluation using the prognosis score, and considering other specific prognostic indicators together with the surgeon's clinical expertise led to the optimal decision making process. The "MESS" prognostic score, which is considered antiquated, is not a reasonable criterion for essential decision making about proper treatment.[10,12] Therefore, we used the SATTy scoring system, which considers more elements than the "MESS." Some studies indicate that the results of amputation and limb salvage procedures are similar, whereas amputation may be more advantageous. Providing guidance to patients on the most beneficial treatment options is crucial in order to enable them to make well-informed decisions.[16] Another concern is if the ultimate objective is to achieve the functionality of a well-formed stump or have a nonfunctional limb.[7]

Within our department, we used the orthoplastic approach for the purpose of flap-based limb salvage surgery.[20]

Table 2
Data of the Patients Involved in the Present Study*

NR	Age (y) Sex	Severity	Anatomy	Topography	Type	Level	Etiological Factor	Affected Bone	Other Affected Tissues	Initial Surgery	Complications Second Reconstruction	Late Reconstruction	MMTGS Results	DASH Results†
1	23 Male	S2	A2	Amputation	S2A2T3 Ty2	Right forearm	Blast firework	Radius Ulna	Amputation	Skin Closer of the stump			Nil	5 metacarpals
2	10 Male	S2	A2	Amputation	S2A2T3 Ty2	Right forearm	Blast firework	Radius Ulna	Amputation	Skin Closer of the stump	Restricted area stump necrosis	Necrosis excision STSG	Nil	5 metacarpals
3	46 Male	S2	A2	Bilateral amputation	S2A2T3 Ty2	Forearms bilateral	Blast dynamite	Radius Ulna	Amputation	Skin Closer of the stump			Nil	5 metacarpals
4	16 Male	S2	A2	Amputation	S2A2T3 Ty2	Left distal forearm wrist	Blast firework	Wrist joint	Amputation	Skin Closer of the stump	Restricted area stump necrosis	Necrosis excision Stump suture revision	Nil	4 metacarpals
5	26 Male	S2	A2	Four fingers amputation + thumb partial amp	S2A2T3 Ty2	Right fingers	Blast firework	Fingers	Amputation	Skin Closure of the stumps			Poor	4 metacarpals
6	15 Male	S2	A2	Three fingers amputation	S2A2T3 Ty2	Right fingers	Blast firework	Fingers	Amputation	Middle replantation- stump closure index-ring fingers			Poor	4 metacarpals
7	17 Male	S2	A2	Thumb + index amputation Crash first web	S2A2T3 Ty2	Left palm	Blast dynamite	Thumb Index finger	Amputation	Skin flaps Rare (partial) closure	Groin flap		Poor	4 metacarpals
8	32 Male	S2	A2	Thumb First ray amputate Palm crash	S2A2T3 Ty2	Left palm	Blast gun barrel explosion	Thumb amputation + fracture second metacarpal Amputations distal phallanx	Amputation thumb First web crash injury Flexors defects of index, middle	Exfix +extensor tendon repair + radial perforator flap	Exfix removal Tendon flexors grafting attempt by palmaris longus	First metacarpal lengthening By exfix mini- rail device Tenolysis of tendon flexors index middle	Fair	3 metacarpals
9	27 Male	S1	A2	Palm and first web crash lesion	S1A2T2 Ty2	Right palm	Blast firework	First metacarpal stable fracture	Extensor tendon Abductor tendon Adductor muscle Skin defect Palmar medial and dorsal nerves of the thumb	Radial perforator flap Skin grafts Abductor tendon repair Adductor tendon suture	Extensor index proper Transfer to thumb Nerve graft to the ulnar palmar digital nerve defect		Fair	3 metacarpals
10	6 Male	S2	A2A	Three fingers amputated (two rays + one finger) Palm crash	S2A2T3 Ty2	Right palm	Blast firework	Two fingers (rays) + metacarpals + one finger	Amputation fingers	Ulnar flap Skin grafts Fixation of three fingers and one metacarpal by five K-wires	Necrosis of a palmar area Debridement + skin grafts K-wire removal	Tendon deep flexors reconstruction attempt by grafts Index, middle	Poor	4 metacarpals
11	44 Male	S1	2	Palmar Dorsal	S1A2T1+T2 Ty2	Forearm	Labor	Radius Ulna open Fractures Gustilo third grade	Forearm Muscle torsion /avulsion Radial artery thrombosis	External fixation Skin grafts	Infection + granules with antibiotic Third operation - internal fixation	Hardware removal	Fair	3 metacarpals

(*continued on next page*)

Table 2 (*continued*)

NR	Age (y) Sex	Severity	Anatomy	Topography	Type	Level	Etiological Factor	Affected Bone	Other Affected Tissues	Initial Surgery	Complications Second Reconstruction	Late Reconstruction	MMTGS Results	DASH Results†
12	50 Female	S1	A2A	Dorsal Palmar	S1A2T1 Ty2	Right forearm + arm	Labor	Radius Ulna open fracture Galeazzi Wrist luxation Humerus fracture	Forearm Extensors Muscle torsion avulsion	External fixation Radius + humerus Radial perforator transpositional flap STSG	Hardware removal	Tendon transfers for extensor tendons substitution	Fair	3 metacarpals
13	42 Male	S1	A2	Dorsal	S1A2T2 Ty2	Right forearm	Labor	Open fracture Radius	Crash extensors muscle	External fixation STSG	Necrotizing fasciitis of extensor compartment Extensors excision + debridement	Gracilis free transfer for extensors replacement and substitution	Poor	4 metacarpals
14	36 Female	S1	A2	Dorsal	S1A2T2 Ty2	Right arm	Labor	Open fracture Gustilo III humerus	Nerve palsy of musculocutaneous + radial neurapraxia of median nerve	External fixation to the humerus Skin grafts to the arm	Latissimus Dorsi reversed pedicle transfer to biceps (bipolar)	Tendon transfer for radial nerve palsy	Fair	3 metacarpals
15	30 Male	S2	A2	Palmar (+medial) Incomplete amputation	S2A2T3 Ty2	Right arm	Labor (high pressure water injection)		Defects in cm Brachial artery 18 Median nerve 15 Ulnar nerve 10 Triceps, biceps 4	Revascularization saphenous vein Closure of the lesion flaps	Nerve bridging by sural nerve (harvesting bilateral)	Tendon transfer for substitution of the flexor tendons and static tenodesis for hand muscles	Fair	3 metacarpals
16	40 Female	S1	A2	Dorsal (radial)	S1A2T2 Ty2	Right thumb and wrist	Labor	Open fracture + bone defect of first metacarpal	Metacarpal EPL laceration Skin dorsal defect Midcarpal luxation	Exfix fixation of the first metacarpal + two rays stabilization by K-wire Radial perforator flap coverage	Tendon transfer of extensor proper index for EPL substitution + iliac graft of the first metacarpal + two K-wire		Fair	3 metacarpals
17	58 Male	S1	A2	Dorsal	S1A2T2 Ty2	Left hand	Labor	Open fracture second to third metacarpals Dorsal defect	Longitudinal Division of the hand between second to third ray (metacarpals)	Fixation by four K-wires of second to third metacarpal + radial perforator flap	Dorsal limited necrosis of the skin STSG	STSG	Fair	3 metacarpals
18	72 Male	S1	A2	Palmar	S1A2T1 Ty2	Right hand palm	Labor	Wrist subluxation Scaphoid enucleation third ray crash injury Middle Incomplete amputation	Median nerve Laceration Intrisic muscle laceration in palm	Median nerve repair attempt Ulnar flap palm coverage Exfix penning wrist stabilization	Third ray (middle finger) amputation		Fair	3 metacarpals
19	45 Male	S2	A2	Amputation (incomplete)	S2A2T3 Ty2	Right forearm	Labor	Radius Ulna Incomplete amputation	Only a stripe of dorsal skin intact	Revascularization attempt	Ischemia of the limb Revisional anastomosis attempt	Necrosis of the hand Amputation forearm	Nil	5 metacarpals
20	73 Female	S1	A2	Palmar (incomplete) partial amputation)	S2A2T1 Ty2	Left elbow	Labor	Open type-T supracondylar fracture-subluxation of the left elbow	Brachial artery and vein Thrombosis Muscle lesion	3-point fixation Exfix of the elbow Thrombectomy of the brachial artery	Distal humerus malunion, elbow postraumatic arthritis Total elbow prosthesis	Suprainfection of the elbow prosthesis Prosthesis removal Late elbow fusion	Fair	3 metacarpals

21	40 Female	S1	A2	Dorsal	S1A2T2 Ty2	Right wrist hand	MVA	Open fracture distal radius -bone defect+ wrist bones dorsal defect	Dorsal skin defect Extensor tendons defect	Exfix stabilization of the wrist Ulnar perforator flap Extensor tendon reconstruction by plantaris longus	Partial skin necrosis New- radial perforator flap	Late wrist arthrodesis by plate + iliac graft	Fair	3 metacarpals
22	55 Male	S1	A2	Amputation Thumb Index finger	S2A2T3 Ty2	Right hand	MVA	Amputation Thumb Index finger	Skin defect radial hand/wrist	Dorsal interosseus reverse flap	Restricted skin necrosis Free skin coverage		Poor	4 metacarpals
23	43 Male	S1	A2	Palmar	S1A2T2 Ty2	Left hand	MVA	Fractures of the head of third and first metacarpal	Flexor tendons defect (in palm)	K-wires fixation for first, third, and fourth metacarpals	Infection - debridement amputation of the ring finger Ulnar flap coverage	Silicon prosthesis for third metacarpophalangeal prosthesis surgery Silicon rods installation for future tendon grafting	Poor	4 metacarpals
24	40 Male	S1	A2	Palmar (+medial) Incomplete partial amputation	S2A2T2 Ty2	Left arm-elbow	MVA	Supracondylar humeral + olecranon fracture huge bone defect	Brachial artery and median nerve laceration Skin limited defect	Exfix for elbow Anastomosis brachial artery Median nerve suture Skin graft	Total elbow prosthesis	Tendon transfer for thumb opposition Rotational osteotomy first metacarpal for median nerve	Fair	3 metacarpals
25	32 Female	S1	A2	Dorsal	S1A2T2 Ty2	Right distal forearm wrist	MVA	Open Bipolar Radius fracture Ulna styloid fracture Wrist luxation first metacarpal open fracture	Dorsal skin avulsion-defect Extensors tendon laceration	Exfix + K-wire for distal radius fracture ORIF for radius prox fracture, tendon repair, STSG Mini exfix to first metacarpal	Skin necrosis Radial perforator flap	Partial skin necrosis Ulnar Gilbert-Becker flap Exfix removal	Fair	3 metacarpals
26	24 Female	S2	A2	Palmar + Four fingers amputation (incomplete)	S2A2T3 Ty2	Right hand palm Four fingers amputation	MVA	Open fracture of all metacarpals (subcapital) Incompete amputation of all fingers at the proximal phalanx	Crash injury of the palm and four fingers	Fixation by K-wire of all metacarpals and fingers and anastomosis attempt of the third common digital artery	Fingers necrosis Amputation of the four fingers Palm and dorsal hand coverage by ulnar perforator flap	After metacarpals healing K-wire removal	Poor	5
27	35 Male	S2	A2	Palmar (entrance wound)	S2A2T1 Ty2	Right arm	GunShot hunting	Open fracture communitive humerus	Brachial artery laceration Radial nerve lesion	Exfix to the arm Bridging by graft revascularization of the brachial artery	Delate bone healing Bone marrow grafting autologous	Tendon transfers for radial nerve substitution	Fair	3 metacarpals
28	24 Male	S2	A2	Palmar	S2A2T1 Ty2	Right elbow forearm	GunShot hunting	Stable incomplete fracture of the radius	Brachial artery at the elbow, median nerve laceration and flexor muscle defect	Revascularization by saphenous vein graft	Tendon transfer for thumb opposition		Fair	3 metacarpals
29	27 Male	S2	A2	Palmar	S2A2T1 Ty2	Right forearm	GunShot hunting	Stable incomplete fractures of the radius and ulna	Brachial-radial artery severe injury—defect 38 cm Median nerve injury (burn) Skin and flexors muscle defect	Revascularization by saphenous vein 40 cm Plus large STSG	Skin necrosis Vein graft thrombosis Free Chinese flap transfer (through flow flap) from the contralateral limb	First MCP fusion Tendon transfer for thumb opposition	Poor	4 metacarpals

(*continued on next page*)

Table 2 (*continued*)

NR	Age (y) Sex	Severity	Anatomy	Topography	Type	Level	Etiological Factor	Affected Bone	Other Affected Tissues	Initial Surgery	Complications Second Reconstruction	Late Reconstruction	MMTGS Results	DASH Results†
30	32 Male	S2	A2	Palmar	S2A2T3 Ty2	Left forearm	Gunshot hunting	Radius and Ulna cortical incomplete fractures	Radial and ulnar arteries defect Skin and muscle flexors defect Abdominal thoracic lesions	Anastomosis attempt radial artery STSG, splenectomy, bilau (lung lesion)	Distal forearm necrosis Distal forearm amputation		Nil	5 metacarpals
31	74 Male	S2	A2	Dorsal	S1A2T2 Ty2	Right hand	Gunshot hunting	Open fracture 3,4, metacarpal defect	Extensor and flexors tendon of the middle and ring fingers defect Skin defect	Iliac crest graft + two K-wire fixations of the metacarpals Radial perforator flap	Infection Graft removal curettage Groin flap Antibiotic embedded grafts	Groin flap division Silicon rods installation for tendon grafts	Poor	5 metacarpals

DASH, Disabilities of Arm, Shouder and Hand; EPL, extensor pollicis longus; exfix, external fixation; K-wire, Kirschner wire; MCP, metacarpophalangeal; MMTGS, manual muscle testing grading system; MVA, motor vehicle accident; ORIF, open reduction internal fixation; STSG, split thickness skin graft.

* SATTy evaluation system.

† DASH Score, the upper limb DASH score system.

Table 3
Manual Muscle Testing Grading System

Manual Muscle Testing Evaluation System		
Assessement Grade	Result	Functional Condition
M0	Nil	No contraction/no hand (amputation)
M1	Trace	No joint motion/only some visible contraction
M2	Poor	Full ROM against gravity eliminated
M3	Fair/satisfactory	Full ROM against gravity
M4	Good	Full ROM against some resistance
M5	Normal	Full ROM against full resistance

ROM, range of motion.

To achieve this, ensure that there are enough procedures performed at the respective institution and adopt a collaborative orthoplastic approach to preserving limbs.[20] Within this specific institutional context, the occurrence of both flap failure and problems related to flaps may decrease as the number of these procedures performed and the surgeon's level of expertise increases. The anticipated psychological requirements of the patient, and the underlying cause of the damage may influence the treatment choice.[18]

We concluded that blast injuries have a poor prognosis (nil/poor outcomes), with 80% of cases resulting in amputations and limited usefulness. Auxiliary flaps have been used to seal the stumps in an emergency.

For cases involving gunshot or work injuries, we opt for emergency revascularization or flap transfers when we determine that the likelihood of saving the limb outweighs the potential risks of postoperative complications.

In gunshot wound management, we prioritized emergency flaps or revascularization because of the higher survivability percentage compared with blast injuries. Despite the relatively poor ultimate functional outcome, it was deemed worthwhile to save the native limb for many patients from a psychological standpoint.

The MVA injuries of the upper limbs seem to have a relatively less disappointing prognosis than blast and gunshot injuries.

Conflicts of Interest

Dr Ignatiadis is an orthopedic surgeon at Athens, Greece. No benefits in any form have been received or will be received by the other authors related directly to this article.

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