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The role of microsurgical flaps in the treatment of burn patients – a single center experience

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ABSTRACT

Severe burns and electrical injuries pose significant challenges in reconstructive surgery, particularly when vital structures such as joints, tendons, nerves and bones are involved. Effective and timely coverage is essential to minimize complications and improve outcomes. The treatment approach includes methods such as conservative treatment, skin grafts, skin substitutes, local flaps and microsurgical free flaps. Each method has its limitations, especially in compromised tissues, where microsurgical flaps are most suitable. These are rarely used initially in burn treatment, but are more commonly employed in secondary reconstruction to address defects from scar contracture release. Microsurgical flaps offer better functional outcomes and a reduced risk of recurrent contractures compared to skin grafts or local flaps. They are a promising solution for severe burns, but pose a significant challenge to the surgeon. This is because microsurgical failure rates are higher in burn patients due to systemic inflammation affecting haemodynamics and haemostasis. Over the last 6 years, 10 microsurgical free flaps have been performed in burn patients at the East Centre of Burns Treatment and Reconstructive Surgery in Łęczna. The aim of this article is to describe our experience with microsurgical reconstruction in burns and to present a review the available literature.

INTRODUCTION

Severe burns and electrical injuries present a complex challenge to reconstructive surgery, notably when critical anatomical structures such as joints, tendons, nerves and bones are involved. Immediate and effective coverage of these areas is essential to minimize complications and optimize functional and aesthetic outcomes. The choice of treatment method for burn wounds depends on the depth of the burn, surface area, patient's age and co-morbidities. Methods that can be applied include: healing via conservative treatment, skin grafts, skin substitutes and collagen matrices, local plastics, local flaps, free flaps with microsurgical reconstruction. However, local flaps may not be able to be fabricated due to the burn zones and to compromised quality within the surrounding tissue. In such scenarios, microsurgical flaps have emerged as a key technique in the burn reconstruction armamentarium.

Free flap reconstruction is rarely undertaken in the initial treatment of burn patients. This rarity limits the number of cases, surgeon experience and available evidence [1,2]. In contrast, microvascular free tissue transfer is commonly applied in secondary burn reconstruction. Soft tissue defects typically result from the release of burn scar contractures. The use of free flap coverage for these defects allows for the transfer of healthy tissue into the scarred region, resulting in better functional outcomes and a reduced risk of recurrent contracture compared to skin grafts or local flaps.

Microsurgery, introduced in the 1960s and refined over the following decades, has revolutionized the approach to severe burns. This technique allows for the transplantation of well-vascularized tissue from distant sites of the body to the affected area, providing robust coverage and enhancing

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the healing process. By enabling the harvest and transfer of composite tissues (skin, muscle, bone and nerve), microsurgical flaps provide a 'one-stage' solution to complex injuries, reducing the risk of infection, shortening hospital stays and promoting early mobilization and rehabilitation.

This article explores the role of microsurgical free flaps in the treatment of burn patients, examining their indications, timing, principles of flap selection and outcomes. Through a comprehensive review of the literature, we aim to elucidate the advantages and challenges of microsurgical free flaps in primary burn reconstruction, highlighting their potential to transform patient care in this challenging field.

Tissue damage from thermal burns differs significantly from that caused by electrical injury. Consequently, the management of these two types of burn injury requires different approaches. Thermal burns produce tissue destruction at the burn site, penetrating tissue layers in direct proportion to factors such as temperature, duration of exposure and concomitant trauma. In contrast, electrical injuries can damage deep tissue structures and, depending on the path of the current, may cause injury in areas far from the initial site.

Recently, the use of dermal matrices and negative pressure wound therapy (NPWT) has been found to be beneficial. NPWT has made it possible to perform skin grafting around bones and tendons [3,4]. However, this therapy is not beneficial in all cases, because it requires minimal blood supply to the wound bed, which is not possible with e.g. high voltage electrical trauma. Burn units report similar numbers of patients requiring free tissue transfer. Pessoa reported that 1.1% of all patients required free flap reconstruction [5], similar to Platt *et al.* (1.5%) [1] and De Lorenzi *et al.* (1.8%) [6].

MATERIALS AND METHODS

Through the Hospital Information System (HIS), we collected data on patients with burn injuries admitted to the Department of Plastic and Reconstructive Surgery with Burn Unit – from January 2018 to July 2024. A search for the literature up to and including July 2024 was performed using Scopus and PubMed. No language restrictions were placed on the search. The search terms were "burns" + "free flaps" and "burns" and "microsurgery". Titles, abstracts and full texts were filtered to select original articles and reviews describing various methods of utilizing the microsurgical flap technique for burns.

Ethical statement

The tenets of the Declaration of Helsinki were adhered to. This was a retrospective study. The Ethics Committee at the Medical University of Lublin approved both the study protocol and the subject's participation (reference number: KE:0254-244/11/2023).

RESULTS

Among the patients hospitalized from 2018 to July 2024 in our Centre, 10 patients required remediation of tissue defects via free flaps on microanastomoses. The type of burn injury and the treatment applied are shown in Table 1.

The data collected clearly shows that microsurgical flaps are most commonly employed for treatment of burn injury to the upper and the lower limbs, as well as in facial post-burn reconstruction where the damage embraces deeper layers of the tissue. In addition, microsurgical reconstructive procedures tend to be utilized as a useful tool for wound coverage after electrical burns, which, although relatively rare, often cause extensive injury to tendons or bones (the iceberg effect). Scar-plasty using microsurgical flaps is an uncommon alternative to more conventional methods (*e.g.* skin grafting or Z-plasty), but can sometimes give the best possible results in restoring the joint function. The most commonly employed flaps were the anterolateral thigh (ALT) flap and the superficial circumflex iliac artery (SCIA) flap. The main advantages of the employment of these flaps are the primarily closed donor site which rarely requires skin grafting, the long arterial pedicle which helps with harvesting the flap, the large surface of the flap, fewer numbers of dressing changes as compared to other flaps and a better tendency to enable the patient to undergo physiotherapy (resulting in improved joint mobility).

The last patient operated upon in our Centre was the patient presented in the Table 1 as Case Number 10. This patient sustained his burns as a consequence of contact with a high-voltage photovoltaic panel. These turned out to be fourth-degree electrical burns of the right zygomatic and lower orbital area of the face. After his stay in the ICU, the patient was admitted to the burn unit where surgical debridement was performed. Subsequently, the wound was

Table 1. Patients hospitalized in East Centre of Burns Treatment and Reconstructive Surgery from 2018 to 2024 – indications for free flaps and type of the flap used in each case

Case No. 1	Fourth degree thermal contact burn of the foot and right lower leg (1% TBSA)	ALT flap repair of the right lower leg wound and STSG flap repair of the foot wound
Case No. 2	Electrical burn of foot, lower leg and knee	Necrectomy, attempted plastic surgery of the soft tissue defect of the knee with a propeller flap, STSG, plastic surgery of the first metatarsophalangeal joint with a free SCIA flap on microanastomoses from the right groin (artery-vein)
Case No. 3	Post-burn soft tissue loss of the lower leg with exposure of the tibialis anterior tendon	Preparation of the soft tissue defect around the calf and plastic surgery with a free SCIA flap on microanastomoses (end to side)
Case No. 4	Burn scars around the right elbow with a loss of the triceps tendon and damage of the ulnar nerve	Revision, tenolysis, rec. and transposition of the ulnar nerve, reconstruction of the skin and tendon defect with a free fasciocutaneous flap (with fascia lata), ALT on microanastomoses (partial flap necrosis)
Case No. 5	Scars and contracture of the right popliteus	Release of the contracture, SCIA free flap on microanastomoses.
Case No. 6	Burn-related cranial bone defect. Osteomyelitis	Osteonecrectomy, LD free flap with skin island with microanastomoses and STSG
Case No. 7	Burn and crush injury of the forearm	Osteonecrectomy, reconstruction of extensor muscles with a free ALT flap on microanastomoses.
Case No. 8	Fourth degree burn of head and right arm.	Osteonecrectomy, SCIA flap of the temporal area and STSG (partial superficial necrosis of 5% of the flap surface)
Case No. 9	Post-burn deformity of the right foot with loss of the tibialis anterior tendon.	Z-plasty of the Achilles tendon, reconstruction of the tendon of the tibialis anterior muscle with a fascia lata graft, plastic free flap of ALT on microanastomoses
Case No. 10	Fourth degree electrical burn of the right zygomatic and lower orbital region of the face	Scar excision, osteonecrectomy and reconstruction with a free Chinese flap on microanastomoses

Abbreviations: TBSA – Total Body Surface Area, ALT – Anterolateral Thigh Flap, STSG – Split Thickness Skin Graft, SCIA – Superficial Circumflex Iliac Artery, LD – Latissimus Dorsi

covered with a split thickness skin graft (STSG). Finally, a collagen matrix was sewn into the wound to provide its complete coverage. Unfortunately, the matrix's adhesion was insufficient and the central part of the wound remained uncovered with visible bone structure at the bottom of the wound. Therefore, the patient was enrolled for the further microsurgical reconstruction which was performed 3.5 months after the injury. The patient's right zygomatic area of the face was reconstructed via application of the radial forearm free flap (RFFF) technique. Here, the arterial anastomosis was performed using the superficial temporal artery. After few weeks, the flap was completely healed, leaving a satisfactory aesthetic effect except for a slight ectropion of the lower lid of the right eye. This was later reduced using a full-thickness skin graft (FTSG) harvested from the retroauricular area.

Timing

The timing of free flap procedures is critical to success, with varying times for successful flap survival reported in the literature. Some suggest a reduced risk of flap failure if reconstruction is performed soon after trauma [2]. Hypercoagulability, which can occur as early as 48 hours after burn injury, suggests that the risk is reduced when an earlier intervention occurs. This hypercoagulable state has been observed to persist for approximately one week [7]. Therefore, early free flap reconstruction may be advantageous, particularly in burn patients with a single affected extremity who are haemodynamically stable.

In contrast, cardiovascular instability or compromised airways often preclude free flap surgery from being performed before the fifth day post-burn [7]. Flap failure rates for acute burn reconstruction, particularly for surgery performed between days 5 and 21 post-burn, tend to be higher than flap failure rates for other indications such as trauma, breast or head and neck reconstruction [8].

Nowadays, primary reconstruction is rare. Platt *et al.* have reported that only 4 of 604 patients requiring surgical intervention for burns required primary reconstruction with a microsurgical flap. The other 4 required secondary reconstruction to assess burn scarring [1]. The reasons for choosing delayed reconstruction generally fall into two main categories: functional and aesthetic. Indications and contraindications in the case of delayed flap plasty are presented in Table 2.

In our Centre, we performed reconstructions in one patient in the acute phase. The remaining nine patients underwent free flap reconstruction after hospital discharge and readmission – from 3 months to 2 years after the injury. Complete flap necrosis was observed in one patient (10%) in the table described as Case Number 2, and the patient underwent anastomosis on the 11th day after the burn. Contractures were the reason for surgery in 3 of the described cases (30%).

Which flap to choose?

In our Centre, we have utilized ALT (Anterolateral Thigh) and SCIA (Superficial Circumflex Iliac Artery) flaps to cover tissue defects of the lower limb. For upper extremity burns, we employed the ALT flap. Moreover, the LD (Latissimus Dorsi) flap was applied for cranial burns, while the RFFF (Radial Forearm Free Flap) was used for zygomatic and lower orbital facial burns. In such applications, early excision of necrotic tissue and wound closure remain the most important prognostic factors for patient survival. Once the wound has been sufficiently debrided and the surgeon has decided that skin grafts and matrices are insufficient, the second step is to select an appropriate flap. The choice should be carefully considered to maximize patient's benefit. A wide variety of different free flaps are available, including fasciocutaneous flaps, fascial flaps, muscle flaps and combined flaps (conjoined and chimeric flaps) [9]. Fascial flaps offer a flexible, thin and mobile reconstructive option with a dependable blood supply and the potential for sensory restoration. They are particularly applicable for treating soft tissue defects in the hand, neck and scalp. The most commonly adopted fascial flaps are: tensor fasciae latae, radial forearm, lateral arm and temporoparietal flaps [10].

Fasciocutaneous flaps are fascial flaps that include a skin component. These flaps can cover large surface areas, provide a long vascular pedicle and have the potential for reestablishing sensitivity when compared to muscle flaps. Various fasciocutaneous flaps have been described, including commonly used flaps such as the ALT flap, scapular/parascapular flap, lateral arm flap, radial forearm flap and groin flap [9].

Vascularized free muscle flaps have the most reliable vascular supply among all free flaps, and this attribute helps reduce infection risk by improving tissue oxygenation, antibiotic delivery and phagocytic activity. The disadvantages in employing these flaps are the risks of donor site morbidity and loss of function. Examples of the most commonly used muscle flaps are: the latissimus dorsi, rectus abdominis, rectus femoris and serratus muscle flaps [9].

Table 2. Indications and contraindications for delayed free flap plasty in burn cases

Indications for delayed free flap plasty	Contraindications for delayed free flap plasty
the depth of the wound precludes other types of coverage	general contraindications to this type of reconstruction (advanced patient age, uncontrolled diabetes, generalized atherosclerosis, nicotine addiction)
inability to adequately mobilize the surrounding tissues to perform local plasty	systemic infection or significant colonization of the recipient site without adequate wound preparation
deep limb burns, especially circumferential and electrical	lack of suitable recipient vessels or damaged vessels (particularly in the case of the electrical burns and radiation damage, which increase the fragility of the vessel wall and the risk of the anastomotic thrombosis)
inability to cover the important deep structures (e.g. tendons, vessels, nerves, muscles) using other methods	
presence of recipient vessels in the wound area	
functional and aesthetic reconstruction	

There are two main subtypes of combined flaps: conjoined and chimeric flaps. These differ in the physical relationship between their components. Conjoined flap or Siamese flap consists of multiple flap territories that remain dependent due to common physical junction but each has independent vascular supply. Examples are combined myocutaneous flap and microvascular free flaps [11].

Described by Harii *et al.*, the latissimus dorsi–groin flap can be used as an osteocutaneous flap to provide extensive reconstruction of soft tissue. Moreover, it can be applied in situations of bone defects [12]. Chimeric flaps consist of multiple independent territories or flaps connected only by a common source vessel [11]. Combined flaps are valuable for addressing large three-dimensional composite tissue defects that require extensive flap coverage. An example of their use in burns is in treating extensive burn contractures, such as mento-sternal contractures of the cervical neck region [9].

Head and neck

Head and neck burn reconstruction presents the challenge of meeting high aesthetic expectations, while aiming to restore function and spatial structures, as well as symmetry, contour, colour and texture. Typically, chimeric and combined flaps are used and final result involves multistage treatments. Other options are so-called "pre-molded" flaps. These are expanded in the donor area. Their disadvantage is the need for retraction at the recipient site – which is associated with additional surgical procedures [13].

In a retrospective study involving 17 cases of severe facial burns, Rose achieved outstanding aesthetic outcomes using "pre-patterned" composite flaps, with only one instance of flap loss reported. The types of flaps utilized were generally fasciocutaneous or thin free flaps, including preauricular (1), radial forearm (6), ulnar forearm (1), free scapular (6), ilio-osteocutaneous (2), temporoparietal (8), vascularized forehead island (3), supraclavicular (1), and SMAS (1) flaps. A critical factor for achieving optimal results was the quality of the intraoperative "sculpting to simulate normal planes and contours" [14].

The scapular, rectus abdominis and osteomyocutaneous flaps including the fibula, represent a reasonable option for lower face and mandibular region reconstruction [13]. In the surgical treatment of cervicothoracic adhesions, an ideal flap should be thin and long so that it can cover large region and prevent development of contractures.

Tseng *et al.* recommend microsurgical free tissue transfer as a primary method for resurfacing after releasing or excising severe neck burn contractures. To address the soft-tissue defect in the neck of a 41-year-old patient after removing the hypertrophic scar and releasing the contracture, they fashioned a combined scapular/parascapular flap. The scapular section was used to cover the vertical defect, while the parascapular section was applied for the transverse portion of the neck. This enabled achievement of good functional and aesthetic outcomes without recurrence [15].

Similarly, Angrigiani treated 86 patients with neck contracture caused by burns who had undergone scar resection. Here, their tissue defects were covered with a scapular-parascapular flap, and the circumflex scapular artery was anastomosed microsurgically to the facial artery.

In addition, secondary defatting of the submental area and Z-plasty at the distal end was, in some cases, done 30 days after initial surgery and after next 30 days, the vertical portion of the flap was thinned [16].

Pessoa *et al.* fabricated a muscular latissimus dorsi flap to reconstruct the scalp of an 86-year-old woman. Anastomosis was done between the thoracodorsal vessels and the superficial temporal vessels. The split-thickness skin graft was crafted by the authors on the

5th postoperative day [5]. Parett *et al.*, in a study of 36 free flaps used for head and neck burn reconstruction in 32 patients, highlighted the utility and complications of different free tissue transfers. Accordingly, most flaps were created to manage contractures or hypertrophic scarring, with exposure of bone or cartilage being a significant indication for surgery. The more commonly fabricated flaps were ALT and scapular/parascapular, followed by radial forearm, latissimus dorsi and others. Various techniques were employed for tissue transfer, including double vascular pedicles in three flaps, pre-expansion in fifteen cases and prefabrication in fourteen flaps. In one patient, prelamination was used [17].

Upper limb

Fasciocutaneous flaps are often fashioned for covering shallow wounds, visible tendons or joints. The lateral arm flap is commonly employed, either as a sensate composite flap or purely as a fascial flap, and is the preferred choice for covering the dorsum and palmar region of the hand. Scapular and parascapular flaps can be used as composite flaps with vascularized bone for larger defects. Radial forearm flaps are widely applied in upper extremity burn reconstruction but are limited by donor site morbidity. Other flaps such as anterolateral thigh (ALT) flaps, thoracodorsal artery perforator flaps and serratus fascial flaps are also utilized in upper extremity reconstruction.

For larger and deeper wounds, latissimus dorsi, rectus abdominis perforator or gracilis flaps may be adopted, especially when the preservation of the flexo-extension function of the forearm is critical [18]. In a case report comparing the ALT perforator flap to a free gracilis flap for reconstruction, the gracilis flap was found to have a shorter operative time and better aesthetic results. The gracilis flap also was demonstrated to have low donor site morbidity, consistent anatomy with easy dissection and good muscle excursion. Prior to its employment, further reconstruction of the gracilis muscle-tendon complex needs to be performed, followed by the forearm's flexor or extensor muscles reconstruction [13]. Conversely, the ALT perforator flap is bulky, requires more surgical skill, and is less pliable. De Lorenzi *et al.* stated a preference for the application of temporalis fascia flaps for hand burn contractures and arterialized venous free flaps for web spaces or small defects [19]. According to several researchers, early rehabilitation leading to functional recovery of the upper limb is only possible when the injured area is covered with a flap in a single surgical procedure [20,21].

Lower limb

Microsurgical flaps are not usually crafted for lower limb area reconstruction since conventional procedures such as Z-plasty, skin grafts or local flaps are sufficient for treatment. However, injuries leading to joint movement impairment require more advanced procedures [13,21].

Fascial flaps are typically favored for covering the dorsal foot and heel. Superficial temporalis fascia is used for smaller defects, while larger defects are addressed with

serratus fascial flaps. Muscle flaps such as groin, gracilis, rectus abdominis or latissimus dorsi (which is the first choice when the bone exposure occurs) are preferred for plantar foot defects [13]. With regard to ankle burn injuries, the gracilis muscular flap remains the first choice [13]. In contrast, ALT flap is employed to cover larger defects of the leg and the thigh, while lateral arm flap can be applied for plantar region reconstruction with satisfactory functional results.

Damage to the surrounding area of the lower extremity often limits the use of thigh-derived flaps, so other muscle flaps are frequently used to fill wound defects. Ofer *et al.* prefer to use latissimus dorsi or chimeric flaps based on the subscapular system for reconstructing large defects of the leg or the thigh, although they acknowledge that serratus, rectus abdominis and gracilis flaps also provide reliable coverage [19].

Torso

Large defects often necessitate the use of muscle or chimeric flaps, such as latissimus dorsi or rectus abdominis flaps. Smaller defects are typically covered with fasciocutaneous or adipocutaneous flaps. ALT flaps, radial forearm flaps and scapular/parascapular flaps are the preferred choices. For larger defects that cannot be covered with conventional free flaps, pre-expanded parascapular or ALT flaps can be enlisted [19].

To cover the exposed sternum or shoulder blade, a flap with a muscular element is recommended. A significant concern for thoracic burn patients is the impact of their burns on respiratory function, since extensive hypertrophic scarring can restrict thoracic expansion. Anigirian proposed, after scar release and immediate resurfacing with a free flap, using antero-lateral thigh (ALT) flaps for men and deep inferior epigastric perforator or superficial inferior epigastric artery flaps for women. He observed significant improvements in respiratory function, including increased forced vital capacity percentage and forced expiratory volume in the first second and overall thoracic circumference, with minimal complications observed at a 2.5-year follow-up [22].

DISCUSSION

Microsurgery with flap transfer is rarely indicated in burn reconstruction, but has become more relevant in recent years. Flap transfer is chosen when the wound bed lacks a properly vascularized surface. This situation comes about due to non-viability of the skin, e.g. exposed bones or tendons. Flap reconstruction may avoid scar contractures and provide more satisfying aesthetic appearance in some cases. However, the type of burn injury affects the time period in which the flap reconstruction is performed. In electrical burn trauma, the most frequent time of free flap coverage was estimated at less than 21 days after injury. In burn injuries, flap coverage was usually performed up to 3 to 6 weeks after trauma or even in later stages of the course of treatment. High-voltage burns tend to be the most common indications for free flap reconstructions (including limb salvage), and lateral arm flaps and latissimus dorsi (LD) flaps are the most frequently employed for this task. These types of procedures demonstrate usefulness in covering the wound when the injury extends to the deeper tissue layers (such as the muscles or even the bones (iceberg effect)). Microsurgical failure rates in burn patients are much higher due to the alterations in haemodynamics and haemostasis caused by systemic inflammation [23].

Adequate debridement is critical, as only a wound bed completely free of necrotic and infected tissue guarantees successful flap management. Some authors advocate performing serial debridement cycles prior to flap-plasty, while others suggest covering the wound at an early stage – especially when vital structures are exposed [23].

The choice of flap depends on a thorough assessment of factors such as wound size and depth, exposed structures, contamination, mechanism of injury and general condition of the donor site. Fasciocutaneous flaps can provide a gliding surface for tendons and joints and are generally used in shallow wound coverage. Secondary procedures such as tendon reconstruction or nerve grafting can be performed after flap plasty. However, the risk of infection is greater than that among other types of flaps. Examples include antero-lateral thigh (ALT) flap, radio forearm flap (RFF), groin flap, scapular and parascapula,r as well as lateral arm flap [20].

Fascial flaps such as the antero-lateral thigh (ALT) flap, tensor fascia lata flap, serratus fascia flap andmporoparietal fascia flap, are generally used in similar situations as fasciocutaneous flaps. However, they tend to carry some notable disadvantages, including limitation in size (which often requires skin grafting for complete wound closure), hence, increasing the risk of further contraction [23,24].

Muscle flaps are fabricated in order to remediate complex tissue damage. They are considered to be the gold standard for large area size wounds coverage. These kinds of flaps are generally used in highly contaminated areas, since they have a tendency to provide anti-inflammatory factors and increase the oxygenation of the wound bed. However, donor site morbidity seems to be significantly higher and other complications such as hernias, muscle weakness or seroma may occur. The lattisimus dorsi (LD) flap, rectus abdominis flap and serratus muscle flap exemplify these flap types [23].

CONCLUSIONS

Microsurgical procedures involving flap-plasty have traditionally been infrequently used in burn reconstruction, but their relevance has increased in recent years. Indeed, over the last 6 years, 10 microsurgical free flaps were performed on burn patients at the East Center of Burns Treatment and Reconstructive Surgery in Łęczna, Poland.

The main indication for the need to incorporate microsurgical flaps in burn treatment are: presence of situations of inability to cover important deep structures such as tendons, vessels, nerves, muscles and post-burn contractures when using other methods. However, these techniques require a very good selection of patients so as to achieve optimal, complex and aesthetically satisfying outcomes (e.g. recipient vessels have to be precisely assessed and thoughtfully selected). In addition, optimal timing of microsurgical

reconstruction seems to be crucial when it comes to primary wound coverage. Moreover, the complication rate tends to be much higher when compared to other surgical procedures. Still, sometimes utilizing this type of treatment is counterbalanced by various advantages such as maintenance of massive limb injuries. Microsurgical flap reconstruction can also be useful in the management of post-burn scars as it ensures a low risk of further contractures.

Figure 1. Case No. 10: Fourth degree electrical burn of the right zygomatic and lower orbital region of the face. A – The Patient admitted to the burn centre 6 days after the accident

Figure 2. Case No. 10: Fourth degree electrical burn of the right zygomatic and lower orbital region of the face. B- Condition after wound debridement using a water knife

Figure 3. Case No. 10: Fourth degree electrical burn of the right zygomatic and lower orbital region of the face. C – STSG was performed with collagen matrix sutured to the central part of the wound

Figure 4. Case No. 10: Fourth degree electrical burn of the right zygomatic and lower orbital region of the face. D – Patient's right zygomatic area of the face was reconstructed with the radial forearm free flap (RFFF)

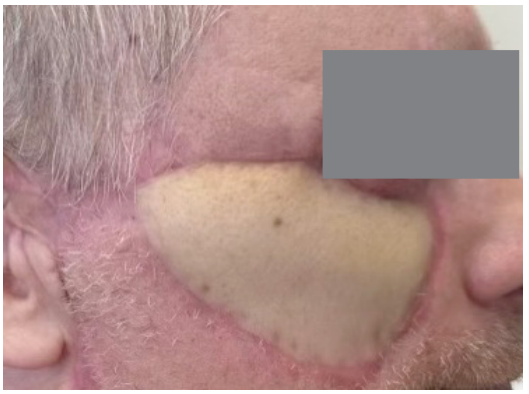

Figure 5. Case No. 10: Fourth degree electrical burn of the right zygomatic and lower orbital region of the face. E – Final effect, 9 months after the accident, before reduction of lower lid ectropion

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