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Original Research Article

Reconstruction of Post Electrical Burn Soft Tissue Defects With Loco-Regional Pedicled Flaps: An Observational Study

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ABSTRACT

BACKGROUND
Electrical burn injuries are more severe than thermal burns as they often extend into the subcutaneous tissue and cause necrosis of muscle, tendon and bone. Moreover electrical burns can occur at multiple sites requiring multiple staged procedures and reconstruction of soft tissue defects. Managing these defects, which expose vital structures, is challenging and must be tailored to the individual patients situation. Among various options for resurfacing the electrical burn wounds, pedicled loco-regional flaps offer simplest solution to cover exposed vital structures such as bones, tendons and vessels.

AIMS AND OBJECTIVES
1. To find out simple loco-regional pedicled flap options to cover complex soft tissue defects caused by electrical burns involving different anatomical regions.
2. To study versatility and utility of pedicled flaps in electrical burn reconstruction.
3. To study the complications and management of pedicled flaps.

METHODS
The present study was conducted in the Department of Plastic Surgery, King George hospital, Vishakhapatnam from March 2024 to May 2024 for a period of 3 months.

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

Electrical burns patients with soft tissue defects exposing vital structures, reconstructed by pedicled loco-regional flaps were included in the study. Patients requiring different resurfacing options from skin grafting to free flaps were excluded in the study. Electrical burns patients not giving consent for the study and patients who require amputations are excluded from study. A total number of 30 patients of electrical burns who require loco-regional pedicled flaps were included in the study after preoperative consent and necessary documentation.

RESULTS

Among 30 patients included in our study, males were more prevalent (25 men and 5 women) with a male to female ratio of 5:1, as trauma requiring flap cover was dominantly high in males. The median age was 33.6 years (range 16- 60). The median duration of hospital stay was 8 days (range 4-18). Among these upper limb defects (13) are more in number, scalp defects are 9, upper back and shoulder defects are 4, and lower limb defects are 4 in number. For reconstruction of these defects we have used 9 pedicled flaps for scalp defects, 5 groin flaps for hand and wrist defects, 2 abdominal flaps for forearm defects, 2 cross finger flaps for finger defects (entry wounds), 2 louvre flaps for multiple defects of palmar surface of fingers (contact burn), 2 thenar flaps for pulp defects of finger (entry wounds) and 3 reverse sural artery flaps for plantar defects (exit wounds) 1 medial plantar artery flap for exit wound on plantar aspect of foot. 4 out of 30 flaps (6.6%) were infected in the postoperative period, managed by appropriate antibiotics. In 2 out of 30 flaps (3.3%) we have encountered venous congestion which settled in late post-operative period. Marginal flap necrosis of 2-4 cm was seen in 4 out of 30 flaps (6.6%).

CONCLUSION

An effective and dependable method for rebuilding intricate soft tissue abnormalities resulting from electrical burns is the loco-regional pedicled flap. These can be particularly useful for patients in the hands of young plastic surgeons in emerging burn centers where higher surgical facilities are not available.

KEYWORDS

Post electric burn defect, pedicled regional flaps, transposition flaps, exposed vitals.

INTRODUCTION

Electricity being indispensable energy source in present era, as the use of electricity increases the accidental injuries from it also rises proportionately. All health professionals involved in burn care must appreciate the physiologic and pathologic effects and management of electrical burn injury. Such injuries can take several forms, including electric current burns, flash burns, and contact burns. They can exclusively cause surface damage, but more often tissues deeper underneath the skin are more severely damaged, as a result electrical burns are difficult to accurately diagnose. The type of circuit, the voltage or intensity of the current, the body's resistance, the current's value, the current's course, and the length of contact are the variables that determine how severe the injury is. A deadly injury that can result in significant morbidity and mortality for the person is an electric burn.[1] Its primary mechanisms of action are diffuse cellular necrosis brought on by electroporation and thermal coagulative necrosis. The entire damage caused by high voltage

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

current does not include extensive coagulation necrosis of the skin at the contact locations. Damage to the skin, nerves, blood vessels, muscles, bones, tendons, chest, abdominal viscera, and central nervous system occurs to varying degrees when current passes through the body. As the current passes through the tissue, more heat is produced the more resistive the tissue is. Larger blood arteries typically do not become evident, but mural thrombi develop when the walls are compromised. Hemorrhage and delayed rupture are common. Although they are injured, small vessels could thrombose. Muscles exhibit sporadic necrosis. Many extensive regions of myonecrosis that are not in close proximity to the current flow are caused by tiny artery or vein thromboses, which reduce vascularity.[2]

As a result of this injury, there is exposure and devitalization of underlying vital structures such as bones, joints, tendons and nerves, which can result in permanent disability and limb amputation.[3] This research aims to show how to restore deficiencies resulting from an electrical burn damage that exposes essential tissues using dependable, well-vascularized pedicled flaps. Additionally, it investigates the suitability of loco-regional flaps based on the specific anatomical region affected.

The "reconstructive ladder" should be followed when weighing defect management choices, and the least difficult option should be chosen first. Skin grafting being simplest option in reconstruction is out of scope of this study and not considered in electrical burns exposing vitals. Free flaps are the solution for complex electrical burns involving multiple components of anatomical part involved but because of the non-availability of infrastructure and high learning curve their execution in small and medium range hospitals is questionable.

The Gillies Principle dictates that "Replace like with like," therefore surrounding tissue should be used to reconstruct the lesion.[4] Because loco-regional pedicled flaps are a straightforward surgical procedure that covers the entire defect, replaces tissue with like tissue, preserves anatomical contour with low donor site morbidity, and has long-term durability, we have used them in our clinical trial following debridement.

PATIENTS AND METHODS

The present study was conducted in the department of plastic surgery, King George Hospital, Vishakhapatnam from March 2024 to May 2024 for a period of 3 months.

Inclusion Criteria

Electrical burns patients with soft tissue defects exposing vital structures, reconstructed by pedicled loco-regional flaps were included in the study.

Delay and detachment of flap were done on a daycare basis in the ones discharged early. After discharge, patients were regularly assessed in the out-patient department for progression of functional return and need for some additional surgical procedure.

A total number of 30 patients of electrical burns who require loco-regional pedicled flaps were included in the study after preoperative consent and necessary documentation.

Exclusion Criteria

Patients requiring different resurfacing options from skin grafting to free flaps were excluded in the study. Electrical burns patients not giving consent for the study and patients requiring amputations are excluded from study.

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

RESULTS

A total of 30 patients were included in our study, males were more prevalent in the study (25 men and 5 women) with a male to female ratio of 5:1 as trauma requiring flap cover was dominantly high in males. The median age was 33.6 years (range 16- 60). The median duration of hospital stay was 8 days (range 4-18). Among these upper limb defects (13) are more in number, scalp defects are 9, upper back and shoulder defects are 4, and lower limb defects are 4 in number. For reconstruction of these defects we have used 9 transposition flaps for scalp defects, 5 groin flaps for hand and wrist defects, 2 abdominal flaps for extensive wrist and forearm defects, 2 cross finger flaps for finger defects(entry wounds), 2 louvre flaps for multiple defects of palmar surface of fingers (contact burn), 2 thenar flaps for pulp defects of finger (entry wounds) and 3 reverse sural artery flaps for plantar defects (exit wounds) 1 medial plantar artery flap for exit wound on plantar aspect of foot. 4 out of 30 flaps (6.6%) were infected in the postoperative period, managed by appropriate antibiotics. In 2 out of 30 flaps (3.3%) we have encountered venous congestion which settled in late post-operative period. Marginal flap necrosis of 2-4 cm was seen in 4 out of 30 flaps (6.6%).

Sl. No	Name	Age / sex	Comorbidities	Size & location of defect	Flap used	Complications	Management of complications
1	Apparao	30/m	-	4x3cm scalp	Rotation flap		-
2	Simhachalam	28/m	-	5x8cm forearm	Abdominal flap	Infections	-
3	Laxmana Rao	22/m	-	5x5cm scalp	Transposition flap	-	-
4	Srinivasarao	36/m	-	1x2cm right index	Thenar flap	-	-
5	Varalakshmi	32/f	-	5x6cm right wrist	Groin flap	-	-
6	Rama Rao	36/m	Htn	5x6cm heel	Rsa flap	Venous congestion	Flap adv
7	Krishanaiah	55/m	Htn +dm	8x6cm axilla	Parascapular flap	-	-
8	Harish	16/m	-	1x2cm right mf	Cross finger flap	-	-
9	Kranthi	22/m	-	8x6cm scalp	Transposition flap	-	-
10	Appala Narasayya	50/m	Htn +dm	6x4cm heel	Rsa flap	Venous congestion	Flap adv
11	Satyavathi	32/f	-	3x3cm scalp	Ratation	-	-
12	Vara Prasad	36/m	-	6x6cm wrist	Groin flap	-	-
13	Sanyasappadu	46/m	Htn +dm	14x6cm scalp	Transposition flap	-	-
14	Sivaiah	42/m	Htn +dm	6x8cm palm	Groin flap	-	-
15	Surappadu	60/m	Htn +dm	2x2cm ring finger	Thenar flap	-	-

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

16	Simhadri	21/m	-	2x2cm 3 defects	Louvre flap	Infections	-
17	Appamma	34/f	-	5x6cm heel	Rsa flap	-	-
18	Rama Devi	36/f	-	6x8cm scalp	Transposition flap	-	-
19	Vishnu	21/m	-	18x12cm back	Ld flap	-	-
20	Ramu	38/m	-	5x5cm heel	Medial plantar flap	-	-
21	Kameswara Rao	52/m	Htn +dm	12x8cm forearm	Abdominal flap	-	-
22	Ravi Babu	18/m	-	3x3cm 2defects	Louvre flap	Infections	-
23	Chinnayya	52/m	Dm	6x8cm dorsum of hand	Groin flap	-	-
24	Babu Rao	22/m	-	10x12cm shoulder	Ld flap	Infections	-
25	Venkateswara Rao	40/m	Htn +dm	12x8cm scalp	Transposition flap	-	-
26	Appala Raju	32/m	-	10x6cm first web	Groin flap	-	-
27	Nukaraju	21/m	-	12x10cm upper back	Parascapular flap	-	-
28	Satya Narayana	36/m	Htn	6x8cm scalp	Transposition flap	-	-
29	Sridevi	18/f	-	3x2cm index finger	Cross finger flap	-	-
30	Prabhakar	28/m	-	8x9cm scalp	Transposition flap	-	-

Table 1: Details of various flaps used for post electric burn defects reconstruction involving different regions of the body.

Case 1: Scalp defect transposition flap

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

Case 2: Wrist and hand defect groin flap

Case 3: Posterior heel defect reverse sural flap

Case 4: Palmar finger defect cross finger flap

Case 5: Upper back and shoulder defect latissimus dorsi flap

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

Case 6: Scalp defect double transposition flap

Case 7: Multiple finger defects louvre flaps

Case 8: Lower neck defect para scapular flap

DISCUSSION

One major cause of morbidity in the poor countries is electrical burn injuries. Three to five percent of burn and trauma cases have electrical burns, which have extremely high rates of morbidity and death.[5] The bulk of patients, according to earlier research, are young men. In our patient population, such trauma to the dominant hand in young adults sustained from handling household or workplace wirings with faulty insulation is encountered with reasonable frequency, the average age of our study population being 33.6 years.

Extensive defects of the upper limb involving fingers and palmar area are most common being 13 out of 30 cases (43.3%) because of handling the electrical equipment without proper protection both in accidental household injuries and work place injuries. Most of these injuries

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

involve the hand and wrist as entry point of electricity. Wrist as the bottleneck region of the upper extremity, the involvement of wrist requires high-end vigilance from the burn surgeon's perspective for limb salvage. The wrist is involved in 8 cases (26.6%) in the present study. Scalp defects are the next accounting for 9 out of 30 cases (30%). Electrical injuries of the scalp are a frequent occurrence and electricians working on power lines are the most commonly affected group. The general population is also at risk, because of the ubiquitous presence of overhead live electrical power lines in densely populated areas. Lower limb involvement is comparatively rare only 4 out of 30 cases in our study.

Upper Limb Defects

Multiple finger abnormalities resulting from hand injuries are more common and present a challenge for reconstructive surgeons. They might or might not be connected to finger fractures. Such flaws ought to be removed and replaced with a flap cover as soon as possible.[6]

Since its introduction by McGregor and Jackson in 1972, the pedicled groin flap has remained the workhorse for the coverage of hand, wrist and distal forearm soft tissue defects.[7] Even in the present era of microsurgery, pedicled groin flap has not lost its position and place as a valid reconstructive option. With relatively constant vascular anatomy and ease of harvest, pedicled groin flap has been time tested flap for coverage of hand and wrist defects, especially in the hands of young plastic surgical trainees as well as in emergency settings. It is also being employed in centers where microsurgical expertise and /or equipment is unavailable or unsuitable (e.g. condition of the patient not suitable for prolonged microsurgical procedure). In addition, it can also favorably act as a salvage flap, in failed microvascular flaps.[8] Pedicled groin flap has been a mainstay flap for the coverage of medium to large hand and wrist soft tissue defects. Patients with pedicled groin flaps are reported in the present study. The benefit of the groin flap is that it is harvested quickly and easily; the groin is a much thinner donor site than the flaps of other body areas, especially in obese patients.[9] In addition, because of the potential for more vascular damage by manipulation in the end-to-side anastomosis, it may be beneficial that the circulation of the already injured hand is not further affected, a possible risk of free flaps. Additionally, free flaps need high surgical facilities that are not available in all setups and require a longer operating time; the groin flap is relatively simple to dissect and can also be carried out in emergency settings by young plastic surgeons without much experience.[10]

In this study we report 5 cases of groin flap for wrist and hand defects. Fasciotomy incisions were given in the emergency department for all hand burns followed by serial surgical debridements. After preoperative planning the soft tissue defects are covered by groin flaps, and followed up for next three months for any complications.

The thenar flap can be used to cover volar more extensive pulp losses involving the index, middle, and ring finger.[11] In this study two cases of index and middle finger defects on palmar surface of distal phalanx are reconstructed by thenar flaps.

The cross-finger flap is a dependable procedure that can compensate for a significant loss of the thumb and finger pulp. Unlike the thenar flap, which can only resurface flaws at the fingertip, it can also cover deformities at any level of the digit. The maximal length reaches from the level of the distal interphalangeal joint to the level of the palm digital crease, while the breadth is restricted by the digit's mid-lateral line. The only limitation is the amount of skin that can be

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

harvested from the donor finger.[11] We present two cases of palmar deformities over the middle phalanx of the index and middle fingers that were repaired using cross finger flaps.

Multiple defects involving multiple fingers are more common in electrical contact burns as in accidental grabbing of live electrical wire. Such abnormalities are typically recreated by combining many flaws into one, and a syndactyly was created to provide the flap cover. However, because it requires several operations, including physiotherapy, flap thinning, and syndactyly release, it delays the patient's return to work. The louvre flap is a flexible flap that may cover each finger independently and concurrently. It offers more tissue than a single flap, results in a donor site defect that is superior visually, and allows for a quick return of hand function.[12] This study reported on two occurrences of numerous finger deformities covered by louvre flaps.

Abdominal flaps are more useful in extensive defects of wrist and forearm requiring large flaps to cover defects of size more than 12 cm in largest dimension. Two cases of superiorly based random abdominal flaps were reported in this study. Donor site infection encountered in these cases and is managed by appropriate antibiotics.

Scalp Defects

Vascularized soft tissue covering, a good cosmetic result, and a low rate of donor site morbidity are the objectives of scalp reconstruction. Free tissue transfer or local and regional flaps are two reconstructive approaches for scalp abnormalities. The benefits of local flaps include good color match, reduced donor site morbidity, strong dependability, and a relatively quick operating time.[13] We report the use of a local rotational scalp flap for repair of scalp deformities unsuitable for skin grafting or less complex tissue reorganization techniques. This flap's primary use is for defects where the exposed bone has the pericranium removed. This flap can be directed in any direction with respect to the defect, making use of the scalp's strong vascularity. After the scalp flap is rotated into the defect, a skin graft is applied to the donor location, preserving the peri-cranium. Transferring tissue over or beneath intervening tissue or structures is known as a transposition flap. The inability to transfer tissue is hampered by the absence of tissue flexibility, just as in advanced flaps. The temporoparietal flap, the temporoparietal-occipital (Juri flap), and the parietal temporal post auricular vertical flap are examples of transposition flaps used in scalp reconstruction.[14] For local flap repair of the scalp, rotational flaps, as outlined below, are the most practicable pattern, especially if the defect is larger than 3 cm.[15] Because they are more reliable and leave fewer scars, large, widely based flaps are preferable over smaller combinations of many rotational flaps. These flaps might have their bases on the scalp posteriorly (occipital artery), laterally (superficial temporal artery), or anteriorly (supraclear artery). A minor "back-cut" toward the pedicle together with significant sub-galeal undermining are frequently needed to achieve enough rotation to conceal a bigger defect. The anterior, temporal, and posterior hairlines need to be considered while creating a bigger scalp flap. Ignorance of the flap design surrounding the hairline may result in a visible distortion of the hairline and an unsatisfactory cosmetic appearance. Nine examples of scalp abnormalities, with two rotation flaps (size 3–4 cm) and seven transposition flaps (size 8–14 cm), are reported.

Although this scalp rotating flap approach was effective in our study population, it is not without limits. After an STSG heals in the flap donor site, the color and texture might not be the same as the surrounding tissue. The donor location and nearby scalp have a noticeable height difference. Furthermore, a dog ear malformation usually develops at the base of the scalp flap.

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

Because the flap is made so that the vascular supply passes through the flap base, it is not recommended to remove this unnecessary tissue. Over time, this dog ear settles, and almost all patients reported a satisfactory esthetic result.

Upper Thoracic and Back Defects

Because there are few recipient vessels for free flap repair, regional flaps continue to be the standard procedure for reconstructing posterior trunk lesions. The latissimus dorsi muscle, or myocutaneous flap, supplied by the thoracodorsal pedicle, is considered to be the best-serving muscle in the upper thoracic region, which includes the scapula and the intervening area of the back. The thin, pliable structure of the latissimus dorsi makes it a viable option for many large defects. Furthermore, the donor site morbidity of the latissimus dorsi muscle or myocutaneous flap is minimal compared to same sized free flaps.[16] In patients at higher risk for thromboembolic events following microvascular anastomosis or those with vessel depleted necks, pedicled latissimus dorsi muscle or myocutaneous flaps are appealing alternatives to free tissue transfer. With primary closure of the donor site, para-scapular flaps can be used to restore medium-sized soft-tissue lesions around the scapula's axis. It is the preferable option for abnormalities in the posterior upper thoracic region because it spares the latissimus dorsi muscle[17] and replaces like with like using surplus tissue that covers the lower back. For abnormalities of the upper back and shoulder region, we present two cases of parascapular flaps and two cases of latissimus dorsi muscle flaps.

Defects across the scapula, over the deltoid, and even up to the midline can all be treated with parascapular flaps in a safe and effective manner. The procedure takes only a short while to complete, and there is no need to change positions during the procedure. Other trials have demonstrated that a quicker overall recovery with low functional loss is achieved with minimum muscle dissection, partly because the donor site is closed. The fact that parascapular flaps can only cover faults of 8 to 10 cm is their lone drawback.

Lower Limb Defects

Electrical burns of isolated lower limb are relatively rare and these defects of lower limb are associated with other injuries involving upper limb or scalp. They are usually exit wounds on the plantar aspect of foot as the current passes through the body. The calcaneal region is particularly important when repairing foot abnormalities since it is the foot's pressure point and needs to be covered with thick, textured tissue.

When there are good reasons not to utilize a microsurgical free transfer, the sural reverse flap can be helpful in the rebuilding of the soft tissues of the ankle and foot. An ideal indication of a reverse sural flap may be a defect over the heel or an exposed Achilles tendon. We report three cases of reverse sural flap in our study for covering posterior heel defects. One case of anterior sole defect was covered by medial plantar artery flap.

The most dreaded consequence of reverse sural flap surgery is venous congestion with partial or total flap loss. Nonetheless, comparable risk variables might also result in increased complication rates in free tissue transfer lower extremity restoration. This issue can be resolved with leg elevation, venous supercharging, or the placement of a tiny intravenous catheter in the lesser saphenous vein's proximal stump.[18] Some authors have suggested a reverse sural flap delay method as a means of preventing flap problems.

ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

CONCLUSION

For restoring intricate soft tissue abnormalities resulting from electrical burns, loco-regional pedicled flaps are an effective and dependable solution. These can be particularly useful for patients in the hands of young plastic surgeons in emerging burn centers where higher surgical facilities are not available

Conflicts of Interest
None.
Funding
None 3.

Ethical Approval
Ethical approval taken from institutional ethics committee before conducting the study.

Consent
Written informed consent was obtained from the patients for publication of this original research article and accompanying images.

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ISSN: 0975-3583, 0976-2833 VOL 15, ISSUE 08, 2024

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