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Use of Pedicle Flap in Electrical Injuries with Soft Tissue Defects

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ABSTRACT

Electrical burns account for a small percentage of total burn injuries yet most common cause of functional impairement due to burn. Electrical burns mostly affect extremities coming in contact with power lines or lightning strikes. Early treatment of electrical burns reduces the burden of functional impairment of body parts. The aim of research was the use of pedicaledflap and its effectiveness as a treatment modality. The research was conducted during august 2019 and august 2022 in Dept of Burn and Plastic Surgery, GMC Bhopal. Using variables such as gender, age, type of voltage, site of injury, head injury and groin injury was excluded.

The various pedicle flap included in the study was groin flap an axial pattern flap based on superficial iliac artery.

While evaluating the patient for the research post operative monitoring and follow up was done after 21 days, shickland'scriteria for FDS and FDP was used.

As a result10 patients were treated and taking into consideration various variables, no complete flap necrosis was noted and functional ability was restored in majority of cases and as a result pedicled flap was satisfactory both functionally and aesthetically.

Key Words: *Electrical Injury, Pedicle Flap, Groin Flap, Axial Pattern Flap*

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INTRODUCTION

Electrical burns make up a small percentage, ranging from 1-7%, of all burn- related hospital admissions in India. The hands are a commonly affected body part in electrical burn incidents. High voltage injuries are usually caused by accidental contact with power lines or lightning strikes, while low voltage injuries are more often the result of coming into contact with faulty appliancesor household wiring.

Treating severe burns on the hand is essential to prevent functional impairment, as they can cause significant damage. Severe burns on the dorsumof the hand, where there is little underlying subcutaneous tissue and thin skin may not be suitable for skin grafting due to the exposed bone and tendon. In such cases, flap coverage is necessary to promote healing and restore function.

When it comes to treating soft tissue defects caused by electrical injuries in the hand, pedicled flaps can be an effective solution. One option is the Groin flap, which is based on the superficial circumflex iliac artery. This artery is a long course artery that defines the groin flap as an "axial pattern flap." The flap's design is an ellipse, with the long axis following the presumed course of the artery.

To perform the procedure, the lateral part of the flap (the distal portion) is quickly and easily elevated, without including the aponeurosis of the muscles that are attached deeply by fibrous septa. The lateral border of the Sartorius muscle must be identified, and the elevation can stop at this level. The aponeurosis of the sartorius muscle is then incised to be included in the flap,which helps to protect the origin of the vascular pedicle.

Overall, the Groin flap can be a reliable and effective option for providing coverage in cases of electrical injuries and soft tissue defects in the hand. Theexpertise and precision required to perform this procedure highlight the importance of seeking out experienced and knowledgeable medical professionals when dealing with such injuries.

The aim of this particular study was to assess the effectiveness of using pedicled flaps to cover electric hand burn injuries, particularly in the context of the growing use of free flaps in such cases. The study sought to evaluate the outcomes of using pedicled flaps in these circumstances and to determine whether they remain a valuable option in the current medical landscape.

By examining the results of cases where pedicled flaps were used to cover electric hand burn injuries, the study aimed to provide insights into the efficacyof this approach and to help inform future decisions around treatment options for such injuries.

Overall, the study findings could help to shed light on the ongoing debate around the relative merits of different approaches to treating electric hand burn injuries, and to inform the development of more effective and efficienttreatment protocols in this area.

MATERIALS AND METHODS

This study was conducted at the Department of Plastic Surgery at Gandhi Medical College in Bhopal, with the aim of evaluating the efficacy of using pedicled flaps for the treatment of electric hand burn injuries. The study included patients admitted to the department between August 2019 and August 2022, with details recorded on gender, age, type of voltage injury, and site of injury. Patients with associated head injuries or concomitant injury to the groin region were excluded from the study.

All patients received initial treatment that included intravenous fluid resuscitation and dressing of wounds with silver sulfadiazine. Cardiac monitoring for electrocardiographic changes was performed for 48 hours after admission. Non-viable and poorly vascularized tissues were debrided, and Kirschner wire fixation was used for digit stabilization. Pedicled flaps, including groin and cross-finger flaps, were used for coverage of hand and finger defects with exposed bone and tendon. The donor site was closed primarily in two layers, and adhesive bandages were used to maintain the position of the limb.

Patients were monitored for postoperative complications such as infection and flap necrosis during their average five-day hospital stay. Follow-up assessmentswere conducted on day 21 after discharge to evaluate flap adherence to the recipient bed. Functional outcomes were assessed in terms of the ability to usethe hand for lifting objects, Strickland's criteria for FDS and FDP functions, and writing. Aesthetic satisfaction was evaluated using an ordinal scale during follow-up.

Overall, the study aimed to provide insights into the use of pedicled flaps forthe treatment of electric hand burn injuries, and to help inform future treatment decisions in this area. The findings could also contribute to the ongoing discussion around the use of different approaches to treating such injuries, and to the development of more effective and efficient treatment protocols. The consent was obtained. Details of patient's, operative procedures, investigations and photographs were collected.

RESULTS

According to the study, a total of 10 patients were treated using pedicled flapsfor electric contact burn injuries. The patients included in the study were agedbetween 18 and 42 years, with a mean age of 33. Out of the 10 patients, 9 (90%) were male and 1 (10%) was female.

[Table/Fig-1] shows the distribution of patients according to the type of voltage injury. Low voltage (<1000 volts) electric burn was seen in 2 patients. All low voltage injuries occurred indoor due to contact with the household wires.

Table 1 Distribution of cases according to mode of electric injury

Voltage	Number of patients(percentage)
Low	3 (30%)
High	7 (70%)

High voltage injury (>1000 volts) was seen in Eight patients due to exposure tohigh voltage power lines.
[Table/Fig-2] shows the various areas of hand involvement in the patients. In this study, 10 patients had injury to the dorsum of hand and eight patients hadwrist injury. Right hand was more commonly involved. Associated minor injuries of other areas were managed conservatively with silver sulfadiazine dressing.

Table 2 Distribution of cases according to area involved.

Area involved	**Number ofpatients**	**Percentage**
Dorsum ofhand	2	20%
Palmersurface	2	20%
Fingers	1	10%
Thumb	3	30%
Wrist	2	20%

As per the study, the maximum and minimum lengths of the pedicled flaps used for resurfacing hand defects were 12 cm and 5 cm, respectively. The 12 cm flap was used to cover a larger area of the hand that had been affected by an electric burn injury, while the 5 cm flap was used specifically for coverage of a degloved thumb. The use of different lengths of flaps highlights the versatility of this treatment approach for electric contact burn injuries, as it allows for customized coverage of different types and sizes of defects.

The study reported that while complete flap necrosis was not observed in any of the cases, one patient did experience partial flap necrosis. Additionally, twopatients experienced donor site dehiscence, a rare complication that involves the separation of the edges of the wound at the site where the flap was taken. Another patient had seropurulent discharge from the recipient site, which wasmanaged conservatively and did not result in any major adverse outcomes, except for delayed detachment and insetting of the flap.

According to the study, the only complaint reported by patients was pain, which was effectively managed using simple analgesics. However, in one case, the bulkiness of the flap at the recipient site was a problem that required thinning of the flap after detachment, in a single setting.

Functional outcome was assessed in all patients, with particular attention paidto their ability to use their hand for lifting objects, as well as Strickland's criteria for flexor digitorum superficialis and flexor digitorum profundus functions, and writing ability. The study found that the use of pedicled flaps resulted in good functional outcomes for patients, with most patients able to use their hand for lifting objects and perform activities of daily living.

Additionally, Strickland's criteria for flexor digitorum superficialis and flexor digitorum profundus functions were satisfactory in most cases, and all patientswere able to write.

Aesthetic satisfaction was also assessed during follow-up using an ordinal scale.The study found that most patients reported high levels of satisfaction with the aesthetic appearance of their hand after treatment with pedicled flaps. Overall,the study's findings suggest that the use of pedicled flaps can result in good functional and aesthetic outcomes for patients with hand and finger defects caused by electric contact burn injuries.

Table 3 Distribution of cases according to postoperative complication.

Complication	**Number ofpatients**	**Percentage**
Complete flapnecrosis	01	10%
Partial flapnecrosis	02	20%
Donor sitedehiscence	03	30%
Recipient siteinfection	01	10%

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DISCUSSION

The Pedicled flap is a tried and true method for soft tissue defect reconstruction due to its easy harvest and reliable axial blood supply. However, in the case of electric burn injuries on the hand, the use of groin or cross finger flaps may be preferred to spare the donor area and avoid potential complications with free flaps. The cross-leg flap, first introduced in 1854 and widely used during World War II, has been standardized and found to be useful for lower extremity trauma. While free flaps have become the gold standard for lower extremity reconstruction since their introduction in 1970, the cross-leg flap remains a simple and effective option for reconstructing electric burn injuries on the leg when alternative methods are necessary. It is important for plastic surgeons to carefully consider the specific needs of each patient and weigh the benefits and risks of various reconstruction methods to achieve the best possible outcomes.

The study highlights the use of Pedicled flap groin flap as a reconstruction method for difficult-to-manage cases of electric contact burn of the hand. Cross finger flap and cross leg flap were also used in the study. One of the main challenges was maintaining the limb position until detachment, which required communication and cooperation from family members. The positioning of then flap was crucial for comfortable inset and to avoid dog ears of varying sizes. Tube flap was also used to cover circumferential defects on the thumb and fingers. However, there were concerns about the small area of inset, which could affect the vascularization of the flap after division. The study provides valuable insights into the management of electric contact burn injuries of thehand and the importance of careful flap positioning.

The study identifies a second problem associated with the use of circumferential suturing in tube flap procedures, which can lead to circumferential contracture and the pincushion effect. To avoid this, the researchers used a circumferential inset technique and made a weak cut on thedorsal aspect of the flap. This allowed for a wide flap inset, ensuring adequate vascularization from the edges of the wound and resulting in a wide and interrupted scar, which reduces the chance of contracture. Another precaution to be taken when tubing the flap is to ensure that the seam line, which is the suturing of the flap to form a tube, is not too tight. If the seam line is too tight, it can lead to necrosis and dehiscence of the seam line. The study highlights theimportance of careful technique and attention to detail in avoiding complications associated with flap procedures. The end on flap is another common type of flap used to cover stumps of the hand or fingers.

There are three types of inset possible for this type of end on flap we call it the tip inset the daisy chain inset and the open book inset the tip in set is when theflap is raised and the tip of the flap is sutured to the radial edge of the defect and the sides of the flap envelope the stump of the hand or fingers this is called the tip inset the problem with this tip inset is that the pressure or tension at the tip of the inset is quite high the second type of flap inset for the end on flap is called the daisy chain flap inset here it is used for stumps on multiple fingers when there is an intact skin bridge and in the case of fingers it is the finger webs that are intact in between the inset to the raw areas flap getssutured on to itself this allows for an extra skin to be available when the flap division is done between the fingers that is when the surgical syntactically is released at a later stage this shows an example of multiple end on defects on the fingers for which an end on groin flap with a daisy chain type of insert has been done. After the division after the healing and after syndactyly release the third type of inset for the end on flap is the open book type of inset this is called the open book inset because it resembles the open book and with this opened out book like position the flap inset is done to the raw areas on the stumps of the fingers with the protruding bones the advantage of this type of inset is that there is no undue pressure or tension on any point of the suture line because the pressure is distributed very equally over the entire flap the example to show the use of the open book inset type of end on flap the third type of flap set after tube flap the end on flap is the advancing flap here the leading edge of the groin flap is sutured to the proximal most point on the dorsum of the hand in this flap a wider flap is required to cover the dorsal defect raising the flap correctly doing a correct donor side closure and doing a good flap set is not enough the flap must be taken care of in the post operative period and maintenance of the flap is very important for its survival and reducing the morbidity the first is application of the elbow and arm restraint post-operatively this is usually done in children and if the procedure has been done under general anesthesia because during the time of extubation the patient may move the hand away and cause dehiscence of the suture line if the procedure has been done under regional block anesthesia it is not essential to apply an arm and elbow restraint especially in adults even if this restraint has been applied it is advisable to remove it at the end of 48 hours when the patient is comfortable the next point to be taken care of is the correct positioning of the flap and hand the upper limb must be kept in such a position that the elbow rests on the bed the patient is lying down on this will ensure a stable position of the hand and no instability on the flap this can be achieved by a flap positioning splint which supports the elbow and elevates the forearm the next

important point in taking care of the flap is called flap kneading especially for tube flaps in this flap you can make out that there is a constriction at the level of the pedicle this has happened because the positioning has been uncomfortable and edema has started developing in the flap this must be reduced by the process of kneading it is something like petting the dog's head here gentle movements of the flap especially the tube flap towards the pedicle moves the accumulated fluid down through the pedicle into the circulation this relieves the edema and the flap becomes much safer and less oedematous even after such good care of the flap after the flap division such complications can be noted quite often this happens when the flap division is not done properly so to avoid such complications we have formulated a very practical flap division protocol if the flap inset is clean and there is no dehiscence at all it is better to do a delay of the flap at 14 days and division of the flap one week after the delay is done the insert of the flap that is the final insert can be done 48 hours after the division this is because the groin flap is an axial pattern flap and does not depend much on the revascularization from the edges of the inset so after division it struggles and complications like necrosis of the end of the flap are quite common to avoid this the delay is doneat 14 days at the same time if there has been evidence of flap dehiscence or infection the flap has already undergone a sort of a physiological delay so the division of the flap can be done at two weeks but the insert should again be postponed for 48 hours after the division but if there has been a total dehiscence of the flap or necrosis of the leading edge of the flap advancement of the flap should be done first and division done according to the conditions shown above the procedure of groin slab division should be done under regional block or it can be done under local anesthesia with sedation in compliant adults the donor site should be closed neatly the final flap inset in the hand should not be given if there is any doubt about the vascularity of the divided flap to ensure good management of the divided groin flap the followingshould be done absolute hemostasis should be achieved even a small hematoma in the divided flap can cause a necrosis of the end of the flap if at allsuturing is going to be done it should be very minimal nonadherent dressing should be applied and post-operatively a pop slab should be applied to support both the wrist and the flap dressing change should necessarily be done at 48 hours we need to look for discoloration of the end of the flap if there is any discoloration the suture should be removed any necrotic debris should be removed and a thorough wound wash given if necessary strapping with steady strips can be done if there is evidence of dehiscence if there has been any doubt about the vascularity of the stump of the flap it is better to defer the flap inset for 48 hours the flap inset should alsobe done under local anesthetic for adults or under ga for children the improper positioning has led to a kinking at the base of the flap leading to severe edema on the flap resulting in increased tension in the flap ultimately leading to necrosis of tissues.

In this study, the use of elastic adhesive bandages was successful in holding the limb in position during reconstruction with the Pedicled flap groin flap, cross finger flap, and cross leg flap. While infection and flap necrosis are known complications of groin flap, this study found that seropurulent discharge was manageable with regular dressing and antibiotics. Complete flap necrosis was not observed in any patient, but partial necrosis occurred in two cases, which were promptly addressed with debridement and flap advancement. The donor site was closed primarily in all cases, and while four patients required flexion at the hip and knee joint, donor site dehiscence occurred in only two cases, which were managed with secondary closure at the time of flap detachment and insetting. Overall, the study suggests that proper management and timely intervention can mitigate complications associated with the use of Pedicled flapgroin flap for reconstruction in cases of electric contact burn of the hand.

In this study, the calf was identified as the primary donor site for cross-leg flapreconstruction. The flap was planned by creating a cloth pattern of the defect with a generous margin and including the shortest possible length of the bridge. The limb was kept in a comfortable position, avoiding extreme joint flexion, and planning was done in reverse. The flap was based preferably proximally or anteromedially, depending on the location of the defect, with a proportion of up to 3:1.

To preserve the long saphenous vein and rows of important perforators, a transverse flap based anteriorly on the medial calf was based at least 3 cm behind the medial border of the tibia. After debridement of the defect and freshening of the margin, the flap was raised, including the fascia, and the donor site of the flap was split skin grafted. The flap was then sutured over thedefect, and both limbs were kept in position using an external fixator.

Division of the flap was performed in patients after a mean of 21 days, and inset was done. This study suggests that proper preoperative planning, including careful marking and consideration of the location of the defect, can aid in the success of cross-leg flap reconstruction using the calf as the primary donor site. Additionally, preservation of important structures, such as the longsaphenous vein and perforators, can prevent complications and improve outcomes.

Cross-finger flap is a highly reliable pedicled flap that can be used to cover extensive loss of the pulp of the fingers and thumb. This flap is versatile and can cover defects at any level of the digit unlike the thenar flap, which is limited to resurfacing defects at the fingertip. The size of the cross-finger flap islimited only by the amount of available skin from the donor digit. The width of the flap is limited by the midlateral line of the digit, while the maximum length of the flap extends from the level of the distal interphalangeal joint to the levelof the palmodigital crease.

Overall, the cross-finger flap is a reliable and effective option for reconstructingdefects in the fingers and thumb. It is important to carefully evaluate the amount of skin available from the donor digit before planning the flap, as well as to consider the location and size of the defect being reconstructed. With proper planning and execution, the cross-finger flap can lead to excellent outcomes and improved function for patients with finger and thumb defects.

The cross-finger flap was initially raised as a random pattern flap, with investigators advising a careful consideration of the flap length and width ratio to ensure flap viability. However, in 1990, Strauch and Moura described consistent dorsal branches of the digital artery, which allowed for more reliable flap harvesting. Further anatomical studies by Braga-silva and colleagues identified four constant dorsal branches arising at predictable distances from the proximal interphalangeal joint, allowing for the skin from the dorsum of thefinger to be harvested as an island flap.

In terms of sensory innervation, the dorsum of the finger receives innervation from two main sources. The first is from the dorsal branches of the digital nerve proper, while the second is from branches of either the superficial radial nerve or dorsal branch of ulnar nerve.

Overall, the identification of consistent dorsal branches of the digital artery has improved the reliability of cross-finger flap harvesting. This flap remains a valuable option for reconstructing defects in the fingers and thumb, with careful consideration of flap length and width ratios and an understanding of the sensory innervation of the dorsum of the finger being crucial for successful outcomes.

CONCLUSION

Both the thin pedicle abdominal flap and cross-leg flap are safe and effective options for reconstructing soft tissue defects caused by electric injuries. The thin pedicle abdominal flap is a valid choice when microsurgical techniques are unavailable or contraindicated and not possible, and it remains a valuable option for upper extremity reconstruction. Surgeons in developing countries are encouraged to use this technique while also working towards acquiring the necessary skills and resources for micro-surgery.

Similarly, the cross-leg flap is a reliable alternative to free tissue transfer in certain situations of lower-limb trauma caused by electric burn. It is a versatile flap that can be enhanced with the incorporation of fascia or muscle and the use of external fixators, and it does not require the sophisticated equipment orexpertise of micro-anastomosis.

However, the cross-finger flap does have limitations, such as being a 2-stageprocedure, using an uninjured digit, and potentially causing stiffness in the donor finger. Additionally, it does not provide glabrous skin for coverage.

Despite these limitations, the cross-finger flap remains a valuable option for reconstructing defects in the fingers and thumb, with careful consideration of flap length and width ratios and an understanding of the sensory innervation ofthe dorsum of the finger being crucial for successful outcomes.

In Electrical Burn Injuries there is Immediate damage to vessels and other soft tissue leading to Necrosis and devitilization and also there is ongoing damage tovessels due to Electric poration injury of cells due to passage of current. Therefore immediate microvascular reconstruction is risky in such cases. Regional or distant pedicle flap bring the additional and safe vascularity tothe potentially compromised or ischemic area of defect Following electric burns

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

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