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CASE REPORT

Negative pressure dressing combined with a traditional approach for the treatment of skull burn

N Gümüş

Department of Plastic, Reconstructive and Aesthetic Surgery, Cumhuriyet University Medical Faculty, Sivas, Turkey

Abstract

Deep burns of the calvarium due to high-voltage electrical current present serious therapeutic challenges in the healing. In this study, as an alternative approach to the treatment of burned skull, negative pressure dressing is used to facilitate separation of the necrotic bones from healthy margins of the cranium, and to encourage rapid granulation tissue formation after trephination of the bone. A 36-year-old male patient, who had been seriously injured on his head with high-voltage electrical current, is presented. On the fifth day after injury, necrosis of the scalp became clearly significant, thereby necessitating extensive debridement. Under general anesthesia, necrotic scalp was removed, leaving the calvarial bone exposed, and while devitalized calvaria was left in place, exposed bone was drilled. A vacuum-assisted dressing was then applied to the wound and set to 125 mmHg continuous pressure. Some granulation tissue developed in the holes and margins of the wound, but it was not sufficient to allow successful closure of the wound with skin grafting. Therefore, the patient underwent another operation in which devitalized outer table of the skull was easily removed from viable bone by using a little force. Elevation of the necrotic outer bony layer revealed profuse granulation tissue formation over the inner layer. When dealing with this experience, vacuum-assisted dressing seems to be a useful tool in acceleration of the separation of necrotic bones and stimulation of granulation tissue formation in burned calvarium.

Key words: Bone, burn, negative pressure, skull, trephination

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Introduction

When high-voltage electrical current enters into the body from the head, it often causes deep burns of the scalp and skull, which present serious therapeutic challenges in early and late stages of healing. Besides scalp and calvarial bones, underlying dura and cerebrum may be severely injured; moreover, intracranial hemorrhage with focal neurological deficits, leading to loss of consciousness and sensory and motor deficiencies may occur.

Usually, these wounds are treated by two surgical approaches. First, after performing the necrotic bone debridement sufficiently, calvarial burn wound is covered either with immediate or delayed placement of skin grafts; or with flaps. Second, while burned skull is left in place without removing any necrotic bones, it is covered with a well-vascularized tissue such as pedicled scalp flaps and free muscle flaps.[1-6]

In this report, negative pressure dressing is used in the treatment of burned skull to facilitate separation of the necrotic bones from viable parts of the cranium and develop granulation tissue formation rapidly after trephination of the bone.

Case Report

A 36-year-old male patient presented to the emergency clinic with high-voltage electrical burns. On admission, he had seriously injured his head and lower extremities with

Address for correspondence:
Dr. Nazım Gümüs,
Department of Plastic, Reconstructive and Aesthetic Surgery,
Cumhuriyet University Medical Faculty, Sivas, Turkey.
E-mail: gumus1970@hotmail.com

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high-voltage electrical current which passed from the head down to the lower limbs, resulting in loss of consciousness and sensory and motor deficits of all extremities. The total body surface area burned was 21%. Burned scalp region was 9 × 7 cm in diameter, involving all layers of the scalp and outer part of the cranium.

Initially, management of the patient began with the replacement of fluids using the Parkland formula. In the following days, besides medical treatment, serial surgical debridements were performed for removing deep necrosis of the lower extremities. On the fifth day after injury, necrosis of the scalp became clearly significant, therefore extensive debridement was necessary [Figure 1a]. Under general anesthesia, the whole necrotic scalp was removed, leaving the calvarial bone exposed. While devitalized and burned calvaria was preserved in place, exposed cranial bone was drilled to make a number of holes in the bone, deep down the entire calvarium to allow for the proliferation of granulation tissue through these holes. After meticulously ensuring that there were no signs of cerebrospinal fluid leakage, a vacuum-assisted dressing was applied to the wound and set to 125 mmHg continuous pressure [Figure 1b]. Negative pressure dressing was made of a black polyurethane foam with 400–600 μm pores, transparent adhe sive drape, and a vacuum pump. The cranial wound was reviewed daily for any signs of infection or other local complications. Dressings were changed every 3 days. Some granulation tissue proliferated through the holes and margins of the wound within 32 days, but it was not sufficient to allow successful closure of the wound with skin grafting [Figure 1c]. Therefore, debridement of the necrotic layers of the skull was necessary. The patient underwent another operation in which devitalized outer table of the skull was easily separated from viable bone and removed by application of gentle pressure. With elevation of the necrotic outer table, profuse granulation tissue appeared clearly over the inner table of the skull, suitable for skin grafting [Figure 2a]. Then, the fully granulated wound without exposed bone was covered with a split-thickness skin graft [Figure 2b–d].

Discussion

Although calvarial burn is a rare injury resulting from high-voltage electrical burns, it destroys frequently both soft tissues and bony parts of the head. Outer layer of the cranium is usually the most affected part of the bony structure; however, injury sometimes deepens to the inner table of the bone, resulting in full-thickness calvarial burn. In the management of soft tissue defects of the head due to burns, either scalp flaps or skin grafts are used to cover the wounds. Free flap is another versatile alternative in the treatment. Burned parts of the calvarium could be treated by either bone debridement in superficial burns or craniectomy in full-thickness burns.

Dalay *et al*. reported 15 patients with various scalp defects resulting from contact electrical burns, of which reconstruction included 4 free flaps, 1 pedicled flap, and 10 local flaps. They concluded that early surgical attempts when made to cover the defect with a well-vascularized tissue provides excellent healing, osteogenesis, short hospital stay, low rate of infection, and requires no surgical debridement of the bone.[7] Spies presented 27 children with scalp burns extending at least into the outer table of bone, who were treated with either bone debridement and placement of autograft skin, or local scalp flaps. The report concluded that acute calvarial burns could be managed by bone debridement in combination with staged autografting or early flap coverage.[8] Srivastava presented chronically exposed calvarial electrical burns to give his experience of 14 such cases, explaining the reasons for the chronic state and their subsequent clinical management.[9] Chavoin reconstructed cranial electrical burns involving scalp, bone, and dura by using homograft, free groin flap, and cranioplasty.[10] Caffee managed a case of electrical injury with the transposition of the omentum with vascular anastomosis and skin grafts.[11]

Primary coverage of the devitalized calvarial bone using flaps such as pedicled or free flaps is probably the most important procedure for the management of burned

Figure 1: (a) Appearance of the deep scalp necrosis due to high-voltage electrical injury, (b) After removing the whole necrotic soft tissue, devitalized calvarium was drilled and a vacuum-assisted dressing was applied to the exposed skull, (c) View of the skull wound 32 days after the beginning of negative pressure dressing. Note that granulation tissue became apparent in the holes and margins of the wound, but it was not sufficient to allow successful closure of the wound with skin grafting

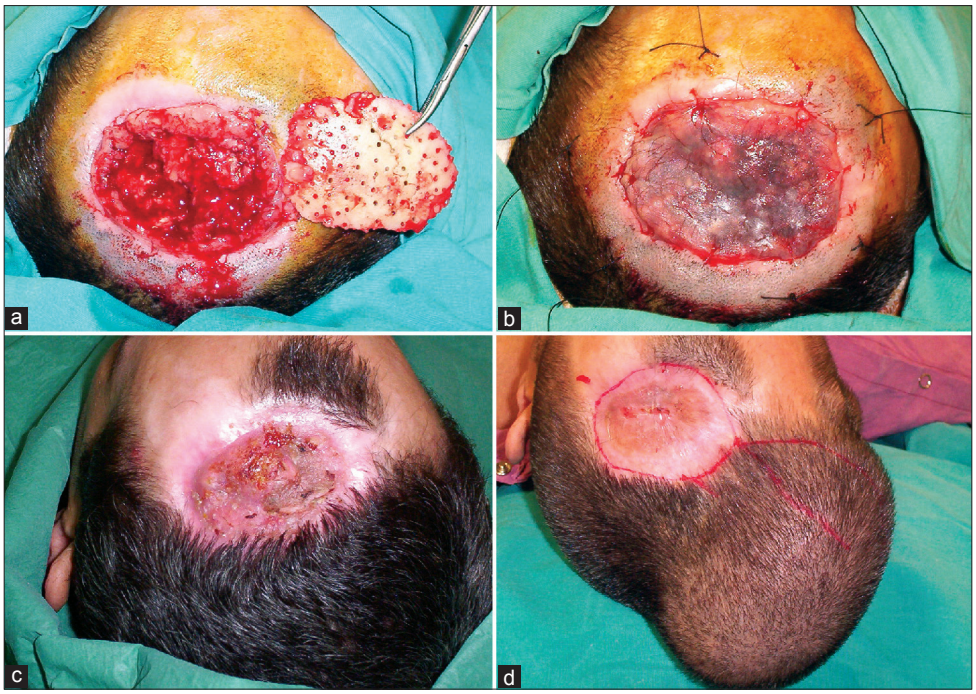

Figure 2: (a) Appearance of the wound just after removing the devitalized bone. There was significant granulation on the wound bed, (b) Intraoperative view of the wound which was covered with a split-thickness skin graft, (c) Appearance of the wound 24 days after skin grafting, (d) View of the head 4 months later. Note that scalp expansion was performed by using a tissue expander for hair restoration surgery

skull, leaving the necrosed skull *in situ* as a scaffold for bone regeneration. While primary healing of the scalp wound is being provided by a well-vascularized flap, bone regeneration develops gradually in burned calvarium with increased blood perfusion. Sarıkaya presented a case of electrical burn of the skull for the assessment of bone regrowth and muscle flap viability after application of latissimus dorsi free flap. Bone and muscle scintigraphy with 99mTc methylene diphosphonate (MDP) and 99mTc sestamibi were used. Although 99mTc MDP bone single-photon emission computed tomography (SPECT) showed absent uptake after the flap coverage of the burned bone, there was good uptake 3 months later, revealing bone regeneration.[1] Bizhko treated 22 patients with deep burns of the scalp, whose management included early excision of necrotic soft tissues without bone resection and immediate coverage with well-vascularized axial flaps from adjacent scalp. Bone regeneration was confirmed by radiological investigations.[2] Hartford presented three patients with necrosis of the skull due to electrical injury, of whom treatment consisted of excision of overlying necrotic soft tissue and immediate coverage of the devitalized bone with flaps. In every patients, follow-up bone scintigraphy showed regeneration of bone, which suggested that devitalized, but intact calvarium did not need to be removed.[3]

However, in some studies, late complications and drawbacks related to early coverage of the devitalized calvarial bone with flaps are presented, suggesting that resection of the devitalized skull and later reconstruction with either autolog bone graft or alloplastic material are curative. Gümüş reported a case of calvarial burn due to high-voltage electrical injury, presenting cranial bone sequestration 3 years after flap coverage of the skull.[4] Rockwell reported a 28-year-old male who sustained cranial electrical injury. Although bone coverage was performed with a free muscle transfer, in the follow-up, secondary infection of the skull developed, leading to bone defect.[5]

As it is well known, traditional treatment of the burned skull consists of excision of necrotic soft tissues and trephination of the bone to allow developing granulation tissue formation and spreading it over the devitalized bone. However, it takes a long time such as a few months to grow sufficient granulation tissue suitable for skin grafting. Also, in many cases, debridement of necrotic bone is necessary before skin grafting. In this case, traditional treatment of the burned skull was combined with vacuum-assisted dressing to develop granulation tissue rapidly. At the first sight, it seemed that there was not enough granulation tissue to allow skin grafting, but after removing devitalized bone, significant granulation tissue became evident. This approach significantly impacted on timing of wound closure. Vacuum-assisted dressing reduces edema, stimulates granulation tissue formation and angiogenesis, and prepares the wound bed for closure.[6] In view of the drawbacks about using this

device on drilled calvarial bone, it seems to have a risk of increasing leakage of cerebrospinal fluid if there are signs of it after trephination. So, in case of cerebrospinal fluid leakage, application of the device should be delayed until it stops. With this dressing, not only the granulation tissue developed rapidly within 32 days, but also separation of the devitalized bone from viable bone parts occurred, helping the surgeon remove the parts of the devitalized bone easily.

Conclusion

When dealing with this experience, vacuum-assisted dressing seems to be a useful tool in accelerating the separation of the necrotic bones and stimulation of granulation tissue formation in burned calvarium. In patients who will be treated conservatively with a few surgical interventions and early debridement of burned skull, this combination may be considered as an alternative approach in the management of skull burn.

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